SACRAMENTO REGIONAL WASTEWATER TREATMENT PLANT
NPDES PERMIT RENEWAL

TESTIMONY/COMMENTS OF HUGH STEPHEN MCDONALD
CAROLLO ENGINEERS
On

THE COSTS OF TREATMENT AND FEASIBILITY OF COMPLYING WITH CERTAIN EFFLUENT LIMITATIONS PROPOSED IN WASTE DISCHARGE REQUIREMENTS FOR THE SACRAMENTO REGIONAL COUNTY SANITATION DISTRICT
SACRAMENTO REGIONAL WASTEWATER TREATMENT PLANT

On behalf of the

SACRAMENTO REGIONAL COUNTY SANITATION DISTRICT (SRCSD)

I am Hugh Stephen McDonald. I am a registered Civil Engineer (C44074), and Mechanical Engineer (M20740) in the State of California. I am a Partner at Carollo Engineers (Carollo), and Director of the Integrated Water Resources (IWR) Group. I have over 30 years of engineering experience in the field of planning and designing wastewater treatment facilities, including design of liquids treatment, biosolids treatment and reuse/disposal and energy systems, financial analyses, asset management, optimization modeling, cost estimating, and preliminary design for wastewater treatment facilities. A copy of my resume, which accurately describes my education and representative experience in wastewater treatment plant planning, design, and optimization, is attached hereto as Exhibit A.

BACKGROUND

Carollo Engineers has issued various reports, Technical Memoranda, and Project Memoranda that have been submitted to the Regional Water Quality Control Board, Central Valley Region (Regional Board), on behalf of the Sacramento Regional County Sanitation District (District). These include, a Technical Memorandum titled, *Advanced Treatment Alternatives for the SRWTP* (March 2009) (*Advanced Treatment Alternatives* Technical Memo) that was submitted to the Regional Board on May 27, 2010, as part of and with a Technical Memorandum titled, *Analysis of Costs and Benefits of Advanced Treatment Alternatives for the Sacramento Regional Wastewater Treatment Plant (Analysis of Costs / Benefits* Technical Memo), prepared by Larry Walker Associates. The *Advanced Treatment Alternatives* Technical Memo identified planning level effluent concentrations for five different treatment trains, and developed planning project and operation and maintenance costs for the five different treatment trains. The *Analysis of Costs/Benefits* Technical Memo along with the *Advanced Treatment Alternatives* Technical Memo were submitted to the Regional Board for consideration in the Regional Board's NPDES permit renewal process for the District's Sacramento Regional Wastewater Treatment Plant (SRWTP).

I am aware that Regional Board staff requested PG Environmental, LLC (PG Environmental) review the information contained in the *Advanced Treatment Alternatives* Technical Memo. Based on their review, PG Environmental issued two different memoranda to Regional Board staff documenting the results of their review. Also, the Tentative Permit, as prepared by Regional Board staff, proposes an effluent limitation of 0.26 mg/L-N for nitrate based on a planning level value used in the *Advanced Treatment Alternatives* Technical Memo.

Upon review of the PG Environmental memoranda and the Tentative Permit, Carollo, under my direction and supervision, prepared three additional project memoranda: *Comments on the nitrate and ammonia effluent limit in the SRWTP Tentative Order R5-2010* (Sept. 30, 2010) (attached hereto as Exhibit B); *Responses to PG Environmental, LLC Comments on the "Advanced Treatment Alternatives for the Sacramento Regional Wastewater Treatment Plant"* (Sept. 28, 2010) (attached hereto as Exhibit C); and, *Review of Project Memorandum titled: "Verification of Estimated Microfiltration Costs for Proposed Changes to the Sacramento Regional Wastewater Treatment Plant"* (Sept. 28, 2010) (attached hereto as Exhibit D).

Below, I provide analysis and my conclusions and opinions with respect to the following topics:

1. My role as an expert in developing advanced treatment process trains to target removal of specific pollutants for the District;
2. Planning-level pollutant removal efficiencies for treatment process trains;
3. Planning-level cost estimates for treatment processes and treatment trains;
4. Comments received from PG Environmental, LLC on the development of advanced treatment trains for the SRWTP; and
5. The Tentative Permit's proposed use of the planning level concentration of nitrate as an effluent limitation.

My analysis and conclusions are based, in part, on my training and experience in master planning wastewater facilities, upon my familiarity and intimate knowledge of the SRWTP processes and performance, and upon the findings and conclusions presented in the technical memoranda, studies, and reports prepared by Carollo.

PRIOR WORK ASSOCIATED WITH WASTEWATER TREATMENT FACILITIES AT THE SRWTP

I have had an understanding of the SRWTP since 1989, when Carollo began work on the master planning of future facilities for SRCSD. Through 2004, Carollo, under my supervision, performed the engineering work for the District's 2020 Master Plan for the SRWTP. In 2002 and 2004, I was responsible for the preparation of new capacity rating studies for the SRWTP. There had been several changes to the SRWTP over the years, including improvements to existing facilities, revisions to the influent wastewater characteristics, and modifications to operational procedures. The potential impact of these changes on increased plant capacity needed to be considered pending the planned (2007) annexation of the City of West Sacramento and other circumstances.

In 2004 and 2005, I was responsible for preparation of the District's Treatment Feasibility Studies (March 2005), which was prepared to comply with provision E.6 of Order No. 5-00-188. The requested information from the Regional Board originated with the District's submission of the "Work Plan for reducing Pollutant Loads to the Sacramento River" (Work Plan) in October 2001. The Work Plan examined ten processes for advanced treatment for the removal of mercury, chlorpyrifos, diazinon, and lindane. From the ten, the District selected three alternatives (chemical addition, media filtration, and reverse osmosis (RO)) for further analysis. Based on a series of progress reports and correspondence with the Regional Board after submittal of the Work Plan, granular activated carbon (GAC) was added to the list of potential advanced treatment processes and additional information on the four potential processes was requested. This report was structured to respond to the information requested by the Regional Board.

In addition to being responsible for the District's Treatment Feasibility Studies, I was also responsible for development of a Technical Memorandum for the District titled, *Evaluation of Selected Advanced Wastewater Treatment Processes*, which was submitted to the Regional Board in March of 2005. The purpose of this technical memorandum was to identify and evaluate advanced wastewater treatment processes that target the removal of total dissolved solids (TDS), total organic carbon (TOC), pathogens, and nutrients. The overall approach included a review of treatment trains and the rationale for the need for these treatment trains as developed for the SRWTP 2020 Master Plan, the supporting master planning Technical Memoranda (TMs), and the 2020 Master Plan EIR. In this analysis, the approach to development of treatment trains targeted the removal of TOC, TDS, nutrients, and pathogens, but considered other constituents of interest, as well as feasibility/operation issues associated with implementing potential advanced treatment processes at SRWTP.

I was also responsible for development of a Technical Memorandum titled, *Update of Estimated Project Costs for the SRWTP 2020 Master Plan Advanced Treatment Alternatives*. The Master Plan identified four treatment train scenarios for pollutant reductions for which estimated project costs were developed. In order to reflect recent changes in technology and marketplace changes, these treatment processes were revisited and costs reevaluated. The Technical Memorandum identified here provided updates to the estimated project costs for the advanced treatment trains. To develop the costs, review of unit processes, design criteria and analysis of pollutant removal efficiencies were included. Pollutant removal efficiencies for pollutants considered in the SRWTP 2020 Master Plan were estimated. Planning-level capital cost estimates were updated for the advanced treatment alternatives.

FINDINGS AND CONCLUSIONS FROM THE *ADVANCED TREATMENT ALTERNATIVES* TECHNICAL MEMO AND FROM MODIFIED FLOW ASSUMPTIONS

Purpose of the Technical Memorandum

I am responsible for preparation of the *Advanced Treatment Alternatives* Technical Memo. This Technical Memo includes planning-level analyses of advanced treatment technologies for removal of various target pollutants (TPs). These include: biochemical oxygen demand (BOD), total suspended solids (TSS), TDS, TOC, ammonia-nitrogen, nitrate-nitrogen, total Kjeldahl nitrogen (TKN), total phosphorus, total recoverable copper, and total mercury. In addition, trace organic compounds, including endocrine disrupting compounds (EDCs) and pharmaceuticals and personal care products (PPCPs), are qualitatively evaluated using a "limits of technology" approach to identify the appropriate advanced treatment processes to treat a broad range of trace organic compounds. Different levels of effluent quality were based on a range of possible future NPDES permit requirements for the SRWTP.

Approach

To provide the District with the appropriate background information, five different treatment trains were developed that were designed to remove different pollutants or combinations of pollutants to achieve different levels of effluent quality. The treatment trains developed and evaluated in the *Advanced Treatment Alternatives* Technical Memo included:

- Treatment Train A (Title 22 Treatment) – Microfiltration (MF) and UV Disinfection (UV): The treatment rationale was to implement treatment that will produce treated effluent that meets Title 22 tertiary standards.
- Treatment Train B (Nutrient Reduction) – Nitrifying Trickling Filters (NTF), Fluidized Bed Reactors (FBR), and Chlorine Disinfection: The treatment rationale was to significantly reduce nutrients in SRWTP's entire flow.

- Treatment Train C (Nutrient Reduction + Title 22 Treatment) – NTF, FBR, MF, and UV Disinfection: The treatment rationale was to produce treated effluent that meets Title 22 tertiary standards and significantly reduces nutrients in SRWTP's entire effluent flow.
- Treatment Train D ("No Net Increase") – MF, RO, and Ozone/Peroxide (Partial Flow): The treatment rationale was to produce "no net increase" in loading of pollutants to the Sacramento River resulting from a 218 mgd ADWF discharge as compared to a 181 mgd ADWF discharge. Ozone/peroxide, in conjunction with RO, was added to the treatment train as these two processes provide multiple barriers of protection for the removal of trace organics.
- Treatment Train E (Full RO and Ozonation) – MF, RO, and Ozone/Peroxide (Full Flow): The treatment train rationale was to go beyond the "no net increase" treatment train to provide removal of all target pollutants from the full flow of the SRWTP.

Further, planning level project and operations and maintenance (O&M) costs were developed and included in the *Advanced Treatment Alternatives* Technical Memo. In addition, annual costs assuming 3, 5, and 7% discount rates were estimated, future costs were estimated, and present value costs were estimated assuming 3, 5, and 7% discount rates. Capital costs were based on Class 5 and Class 4 estimates as outlined by the Association for the Advancement of Cost Engineering International (AACEI) (formerly known as the American Association of Cost Engineers). The costs presented in this Technical Memo were based on preliminary layouts, preliminary unit process sizes, and conceptual alternative configurations. Construction costs were estimated from unit costs developed from past District construction contracts, estimating guides, equipment manufacturer's information, unit prices, and construction costs of similar facilities and configurations at other locations, where available. O&M costs were based on District and, as available, other similar facilities historical operating costs, estimated manpower needs, resource requirements, and equipment replacement and maintenance needs. The costs developed in this Technical Memo were based on a discharge capacity of 218 mgd, except for Treatment Train D, which was a cost estimate for a "no net increase" in pollutant loadings based on an increase in flow from 181 mgd to 218 mgd (i.e., the incremental increase). Total annual costs were developed using capital costs amortized over a 20-year period using an interest rate of 5% plus annual O&M costs.

This Technical Memo also included estimated removal efficiencies based on reported literature values from academic and professional journals and conference proceedings, published and unpublished pilot plant data, and standard textbook references. The estimated final effluent concentrations presented in the Technical Memorandum are long-term averages for planning purposes only, and are not intended to represent final effluent quality that may be achievable with the treatment train identified, or in establishing permit limits for monthly and daily averages which typically reflect greater variation.

In August of 2010, I was responsible for the development of a project memorandum that modifies the cost estimates in the *Advanced Treatment Alternatives* Technical Memo based on a modification of flow from 218 mgd to 181 mgd. The project memorandum titled, *Modification of Flow basis for treatment train costs as previously presented in the "Advanced Treatment Alternatives for the Sacramento Regional Wastewater Treatment Plant"* was submitted to the Regional Board on August 19, 2010.

Conclusions

Based on the analysis presented in the *Advanced Treatment Alternatives* Technical Memo and as modified by the project memorandum to reflect the change in flow, Carollo estimated the planning level total project costs for each treatment train.

In general, it is important to keep in mind that at the time the *Advanced Treatment Alternatives* Technical Memo was developed, the proposed effluent limitations were not available. Consequently, now that the

proposed Tentative Permit is available, it is evident that there are additional constituents and permit limits that were not considered in the *Advanced Treatment Alternatives* Technical Memo. Also, for some of the constituents that were considered, the proposed effluent limitations and concentrations are substantially different than those anticipated in the *Advanced Treatment Alternatives* Technical Memo. Therefore, the impact of the proposed actual permit limitations must be more fully assessed given this new information, as well as to the following proposed treatment trains and associated costs that were developed based on the potential permit requirements assumed in the *Advanced Treatment Alternatives* Technical Memo.

Nevertheless, the overall findings of the *Advanced Treatment Alternatives* Technical Memo are still relevant in terms of assessing the order of magnitude capital and O&M costs associated with the impact of the proposed Tentative Permit limitations on the SRWTP facilities.

Therefore, with this in mind, and based on a review of the proposed Tentative Permit and the technical analyses we have conducted, I have the following conclusions and opinions. (All of the following costs are in January 2009 dollars: ENRCCI = 9138).

1. Based on the treatment alternatives evaluated in the *Advanced Treatment Alternatives* Technical Memo, the Tentative Permit proposed effluent limitations for coliform, turbidity, suspended solids, and BOD could be met with Treatment Train A, which includes the existing secondary process followed by microfiltration and disinfection. For Treatment Train A, the planning level estimate of the project cost for a capacity of 181 mgd ADWF is approximately $1.2 billion if the existing chlorine disinfection facilities are used, and approximately $1.3 billion if ultraviolet disinfection is used. The planning level estimate of the additional annual O&M costs over and above the O&M costs for the existing SRWTP facilities, for a capacity of 181 mgd ADWF, is approximately $44 million per year if chlorine disinfection is used and approximately $46 million per year if UV disinfection is used.

2. Based on the treatment alternatives evaluated in the *Advanced Treatment Alternatives* Technical Memo, the Tentative Permit proposed effluent limitation for ammonia would require construction of NTFs, although it is uncertain whether this technology would assure compliance at all times. The planning level estimate of the project cost is approximately $580 million. The planning level estimate of the additional annual O&M costs over and above the O&M costs for the existing SRWTP facilities, for a capacity of 181 mgd ADWF, is approximately $15 million per year.

3. Based on the treatment alternatives evaluated in the *Advanced Treatment Alternatives* Technical Memo, the Tentative Permit proposed effluent limitation for nitrate would require at minimum, construction of NTFs followed by FBRs. There is, however, no basis for concluding that this denitrification technology would result in compliance with the proposed effluent limitation for nitrate. In addition, this combination of NTFs and FBRs is based on the assumption that SRWTP would also need to also meet the proposed ammonia limitation (#2 above), and the NTF process would result in increased nitrate levels that would need to be removed through a denitrification process. The planning level estimate of project costs is $780 million. The planning level estimate of the additional annual O&M costs, over and above the O&M costs for the existing SRWTP facilities, for a capacity of 181 mgd ADWF, is approximately $31 million per year.

FINDINGS AND CONCLUSIONS BASED ON PG ENVIRONMENTAL'S REVIEW OF *ADVANCED TREATMENT ALTERNATIVES* TECHNICAL MEMO

I am aware that, at the request of Regional Board staff, PG Environmental, LLC reviewed the *Advanced Treatment Alternatives* Technical Memo, and prepared two project memoranda titled, *Technical Review of Estimated Costs for Proposed Changes to the Sacramento Regional Wastewater Treatment Plant*

(Aug. 18, 2010) [(PG Environmental Technical Review)] and *Verification of Estimated Microfiltration Costs for Proposed Changes to the Sacramento Regional Wastewater Treatment Plant* (Aug. 27, 2010). The technical reviews included comments on the treatment trains identified in the *Advanced Treatment Alternatives* Technical Memo, and suggested modifications to some of the treatment trains.

I am responsible for the development of a project memorandum titled, *Responses to PG Environmental, LLC comments on the "Advanced Treatment Alternatives for the Sacramento Regional Wastewater Treatment Plant"* (dated Sept. 28, 2010, and attached hereto as Exhibit C), which responds to the PG Environmental Technical Review. I am also responsible for the development of a project memorandum titled, *Review of Project Memorandum titled: "Verification of Estimated Microfiltration Costs for Proposed Changes to the Sacramento Regional Wastewater Treatment Plant"* (dated Sept. 28, 2010, and attached hereto as Exhibit D), which responds to PG Environmental's review of estimated microfiltration costs for proposed changes to the SRWTP.

With respect to the PG Environmental Technical Review, I found that the original planning basis from which the *Advanced Treatment Alternatives* Technical Memo was prepared, and the planning basis for the PG Environmental Technical Review differed. As described above, the planning basis for the *Advanced Treatment Alternatives* Technical Memo was based on a range of possible future NPDES permit requirements for the SRWTP. In contrast, the PG Environmental Technical Review focused on the ability of all treatment trains to produce effluent that meets California Department of Public Health (CDPH) requirements for pathogen removal, a nitrate limit of 10 mg/L (as N) and an ammonia limit of 1.8 mg/L (as N).

I also found that the PG Environmental Technical Review did not include estimated O&M costs for its proposed modified treatment trains. To properly consider selection of any advanced treatment facility, the District will need to consider the total life cycle costs that include capital and O&M costs, not just capital costs alone. I also found that the PG Environmental Technical Review failed to review performance of the proposed modified treatment trains as compared to the performance of those identified in the *Advanced Treatment Alternatives* Technical Memo, which is necessary to make any type of "equivalency" determination.

Exhibit D attached hereto contains my opinion and conclusions. The following is a brief summary of my key findings in response to specific comments provided in the PG Environmental Technical Review:

- PG Environmental's comment on Treatment Train E that it is the least cost-effective considering likely NPDES permit requirements, fails to consider the fact that Treatment Train E was developed prior to the release of proposed NPDES permit limitations. It was designed to include removal of all "target" pollutants, including TDS.

- PG Environmental's comment on Treatment Train A that it does not address the removal of inorganic nitrogen fails to consider the fact that Treatment Train A was designed only to meet Title 22 tertiary standards to provide for multiple water reuse opportunities. It was not designed to address the removal of inorganic nitrogen.

- PG Environmental's comment on Treatment Train B that it does not address issues associated with protozoan pathogens, fails to consider the fact that Treatment Train B was designed to significantly reduce nutrients in the SRWTP's effluent, not to produce effluent that would meet Title 22 tertiary standards for reuse.

- PG Environmental's comment regarding proposed cost savings for Treatment Train C with respect to replacing UV disinfection with Ozone/Peroxide Oxidation fails to consider the

following: 1) a non-proprietary ozonation system is not a CDPH approved disinfection technology thus the District would need to demonstrate effectiveness of this process to obtain CDPH approval; 2) UV disinfection is already approved for Title 22 water reuse, which was an objective in developing Treatment Train C; and, 3) project cost estimates for ozone/peroxide were developed in context with Treatment Trains D and E, not Treatment Train C. In Treatment Trains D and E, the ozone peroxide process is preceded by RO, and the assumed ozone dose is 1 mg/L. In the proposed modification to Treatment Train C, ozone peroxide would be preceded by media filtration, and at this level of planning it would be appropriate to assume that the ozone dose would range between 8 to 15 mg/L. At this higher dose range, the project cost for ozonation would be comparable to or greater than project costs for UV disinfection.

- PG Environmental's comment with respect to providing a more refined cost estimate for MF based on the District's previous pilot testing fails to consider that the District's previous pilot testing was not conducted to determine flux rates or other design parameters for sizing MF facilities. Further, Class 5 estimates apply where the level of project definition is 0 to 1% while Class 4 estimates apply when the project definition if 1 to 15%. Considering the lack of project definition at this time, a Class 5 estimate is an appropriate level of definition for the design of a full-scale MF system for the SRWTP.

- PG Environmental provides four alternatives to Treatment Train C that are designed to reduce the costs associated with Treatment Train C. I find that some of these alternatives are not appropriate or applicable for the following reasons: 1) while conventional filtration such as sand filters is an effective approach for meeting Title 22 standards, it does not perform well with the high-purity oxygen activated sludge (HPOAS) process used at the SWRTP; 2) pilot testing at the SRWTP has found that MF more consistently met Title 22 requirements than conventional sand filtration; 3) replacement of UV disinfection with Ozone/Peroxide Oxidation may not cost less because of the higher dose range necessary; 4) the *Advanced Treatment Alternatives* Technical Memo did not investigate modifications to the existing treatment process to improve suspended solids removal because of the uncertainty associated with these kinds of improvements to reliably meet the levels of treatment and pollutant reductions required; and, 5) while operational improvements are worth investigation, the anticipated improvements in the removal of suspended solids with operational changes alone are not considered sufficient, by themselves, in reliably meeting the assumed range of future discharge requirements.

- PG Environmental's comment with respect to Treatment Train D fails to recognize that this was an alternative for "no net increase" between loading of pollutants between 181 mgd and 218 mgd. As previously identified, this alternative is no longer applicable.

- PG Environmental's comments with respect to Treatment Train E fail to recognize that RO was included in Treatment Train E to provide for removal of TDS.

- PG Environmental's proposed modified Treatment Train C would replace MF with mixed media filters and UV disinfection with Ozone/Peroxide disinfection. I find that these proposed modifications are not feasible, or not a cost savings because of the HPOAS process used by the SRWTP, and because of the high dose that would be required for ozone.

- PG Environmental's proposed modified Treatment Train E would remove RO process and substitute NTF and FBR for ammonia and nitrate removal. The modified Treatment Train E provides a reasonable approach to meet the proposed Tentative Permit. However, it would not provide for removal of TDS, which was one of the objectives for Treatment Train E as constructed.

- PG Environmental's general suggestion to conduct pilot studies, with the possibility of using the existing Water Recycling Facility (WRF) to refine cost estimates, is consistent with information contained in the technical memorandum. The investment in advanced treatment at the SRWTP would be significant, and therefore, an upfront investment in pilot testing to refine cost estimates, assess feasibility, and evaluate process performance should be performed and the use of the existing WRF is possible but would depend on the advanced process trains being considered by the District.

- PG Environmental's suggestion that biofilters may be more appropriate as compared to NTF is noted. However, the decision with respect to what is more appropriate should be made during the preliminary design phase, as there are process considerations that exceed the scope of the evaluation in the *Advanced Treatment Alternatives* Technical Memo. Since both are within the range of estimating accuracy, it is sufficient to leave the more conservative cost as a placeholder until a more detailed feasibility assessment is made.

With respect to PG Environmental's *Verification of Estimated Microfiltration Costs for Proposed Changes to the Sacramento Regional Wastewater Treatment Plant*, Exhibit D attached hereto contains my analysis and conclusions. In summary, my opinions are as follows. I found that the eight unit construction cost estimates in the PG Environmental memorandum were not comparable to the total project cost estimates in the *Advanced Treatment Alternatives* Technical Memo, which includes all environmental studies, engineering, legal, administrative, and contingencies to deliver a complete project. I find that the large and precedent-setting scale of the proposed MF membrane for the SRWTP would require a custom designed and constructed superstructure, pretreatment facilities, peak flow equalization basins, and other supporting utilities and structures, and that it is not appropriate to merely "scale-up" smaller MF facilities (i.e., less than 10 mgd). I find that the Gurian and ESCWA references included in the PG Environmental memorandum are probably for mechanical strainers and not for polymeric membranes, and that these estimates ($647 or $7840 per mgd) are not appropriate. I find that the Zenon and Memcor cost estimates are likely equipment costs only. I find that for the remaining four references, inclusive of the MF costs identified in the *Advanced Treatment Alternatives* Technical Memo, the median unit construction cost is $1,991,000 per mgd, and the mean unit construction cost is $2,700,000 per mgd. Based on these findings, it is my opinion that the $2,660,000 per mgd estimate in the *Advanced Treatment Alternatives* Technical Memo is reasonable and appropriate for the construction of a 181 mgd MF membrane filtration facility treating secondary effluent from the HPOAS process at the SRWTP based on a planning-level, Class 5 estimate.

FINDINGS AND CONCLUSIONS BASED ON COMMENTS ON THE NITRATE AND AMMONIA EFFLUENT LIMITS IN THE SRWTP TENTATIVE PERMIT (ORDER R5-2010)

The Tentative Permit for the SRWTP proposes an effluent limitation for nitrate as a monthly average set at 0.26 mg/L (as N). According to the Tentative Permit, this effluent limitation is based on the *Advanced Treatment Alternatives* Technical Memo, which is included as part of the *Analysis of Costs / Benefits* Technical Memo prepared by Larry Walker Associates.

My analysis and conclusions with respect to the Tentative Permit's proposed nitrate limit based on the estimated effluent concentration from the *Advanced Treatment Alternatives* Technical Memo are provided in Exhibit B hereto. In summary,

- The *Advanced Treatment Alternatives* Technical Memo was a planning-level comparison of relative performance of alternative advanced treatment trains. The approach for estimating final effluent concentrations was to use a three-year averaging period and theoretical and literature

value pollutant reductions. The identified effluent concentrations were not developed for permitting purposes.

- The source of the pollutant reduction values was not based on site-specific SRWTP considerations, nor was the application of best professional judgment based on comparing maximum effluent concentrations, or for developing final effluent permit limits for monthly and daily averaging periods.
- The estimated final effluent concentration does not include any consideration of what can reasonably be achieved using a different averaging period (e.g., monthly or daily).

In my opinion, there is no basis to conclude that the average monthly effluent limit of 0.26 mg/L for nitrate in the Tentative Permit is technically feasible with denitrification technology, and the estimated final effluent concentration in the *Advanced Treatment Alternatives* Technical memo is not an appropriate reference for establishing this or any other effluent limit.

H. Stephen McDonald

Education

MBA Finance, California State University, Hayward, 1984

BS Chemical Engineering, Oregon State University, 1978

BS Biology, Portland State University, 1976

Licenses

Civil Engineer: California, Nevada, and Hawaii

Mechanical Engineer: California

Professional Affiliations

American Chemical Society (ACS)

American Society of Civil Engineers (ASCE)

American Water Resources Association (AWRA)

California Association of Sanitation Agencies (CASA)

California Water Environment Association (CWEA)

International Water Association (IWA)

National Association of Clean Water Agencies (NACWA)

San Francisco Planning and Urban Research (SPUR)

Tri-TAC Water Committee

Water Environment Federation (WEF)

American Water Works Association (AWWA)

Mr. McDonald, a partner in Carollo Engineers, is director of Carollo Engineers' Integrated Water Resources Group. Mr. McDonald is recognized in the industry for his contributions to the practice of strategic master planning. This includes the development of sustainable integrated water, wastewater, and stormwater plans; development of decision support software; integration of financial analyses; and the development of fully integrated computer models for scenario development and analysis. He is the creator and developer of the Master Plan Manager (MPM™), Wastewater/Water Asset Manager (WAM™), and *OPTIMO*® computer software applications for planning and optimizing water/wastewater facilities.

Mr. McDonald has directed major strategic planning efforts that have master-planned over $11 billion in wastewater facilities in the last 12 years, involving nearly half the population in Northern California.

Mr. McDonald has a thorough understanding of federal, state, and regional environmental regulations and their impact on the design and operation of water, wastewater, and stormwater treatment and conveyance facilities.

Mr. McDonald is a nationally recognized expert on watershed management and the development of the total maximum daily loads (TMDL) approach. He was selected to the National Research Council (NRC) Committee to assess the science of the TMDL approach to make recommendations to USEPA and Congress on the future direction of TMDL regulations.

Mr. McDonald is an expert in sustainable water practices, including low impact development (LID) and green infrastructure (GI).

Strategic/Master Planning

Mr. McDonald's strategic planning experience includes:

- Project Director for the City of San Jose, California, San Jose/Santa Clara Water Pollution Control Plant Master Plan. This required the planning of over $3 billion of new facilities for liquids and solids treatment over a 30-year master planning for a 167 mgd ADWF advanced wastewater treatment plant, including development of an innovative and sustainable Land Use Plan for the 4.5 square mile plant site. The Land Use plan developed optimum land use elements for endangered species (California Black Clapper Rail and Burrowing Owl), natural wetlands, riparian habitat, and clean-tech commercial, retail, and light industrial development. Carollo evaluated historical treatment plant performance, historical and projected population, and historical and projected recycled water use, developed future regulatory scenarios, and compared plant performance and plant design criteria to assess attainability with future requirements. This effort involved developing public outreach presentations and materials, and interfacing with a wide range of federal, state, and local regulatory and resource agencies to achieve overall consent and support for the recommended Master Plan.

- Project manager for the 30-year Sewer System Master Plan for the San Francisco Public Utilities Commission (SFPUC). This project was a joint venture with Brown and Caldwell, and Metcalf and Eddy. This master planning effort identified the need and timing of over $3.5 billion of future facilities to upgrade and modernize two existing dry weather wastewater treatment facilities (Oceanside Plant and Southeast Plant) and wet weather facilities (including the North Point wet weather plant), several major pumping stations, and over 700 miles of combined collections system facilities. Mr. McDonald provided the overall project management direction for the consulting

team, including conceptualizing the strategic alternatives, facilitating team brainstorming workshops, and developing alternative evaluation criteria and metrics incorporating sustainability principles. Sustainability was the major theme of this master planning effort, and challenges included maximizing the use of existing facilities, addressing "environmental justice" issues, incorporating low impact development (LID) techniques to "green" the City, assessing future regulatory requirements for bay and ocean discharges, assessing the impacts of global warming and sea level rise, public involvement with stakeholders, and development of a financial analysis and addressing aging infrastructure while keeping rates affordable.

- Partner-in-charge/project manager for the City of Davis, California, Wastewater Strategic Master Plan and Preliminary Design. The plan considers alternate discharge locations, including reuse, changes in regulations, and alternative treatment trains to meet regulatory scenarios. Process performance and capacity of existing plant facilities were evaluated. Existing treatment processes include: primary clarifiers, oxidation ponds, aerated ponds, lemna ponds, overland flow, wetlands, digesters, and sludge lagoons.

- Project manager for the Zone 7 Water Agency's Asset Management Study encompassing its three water treatment plants, three pump stations, seven wells, four storage facilities, and the entire distribution system. Tasks included inventorying, assessing, and valuing each asset, developing a program vision, performing a gap analysis and benchmarking research, determining repair and replacement needs, costs, and the rate impacts, developing a decision analytic framework and strategic scenarios, optimizing capital and O&M practices, evaluating information management systems and staffing resources, conducting financial analyses and planning, and developing an asset management program with guidelines and an implementation plan. Tasks also include developing an asset database in Carollo's Water/Wastewater Asset Manager software, and designing an upgrade to the software that includes complete asset assessment information, detailed financial information, time series, and customized queries for reports and graphs.

- Technical advisor for the City of Scottsdale, Arizona, Asset Management Program. This involved assessments of above-ground assets, which included the City's water, wastewater, and groundwater treatment facilities. Carollo developed replacement costs and risk scores for more than 3,000 assets. The above-ground asset study tied into a parallel analysis of buried pipes for the City's entire collection and distribution systems, resulting in a 20-year CIP totaling $500 million. The two-year project encompassed information management, knowledge transfer, risk-prioritization, and developing metrics for long-term optimization of maintenance and capital expenditures.

- Project manager for the Sacramento Regional Wastewater Treatment Plant (SRWTP) 2020 Strategic Master Plan. This is a comprehensive strategic master planning effort for the Sacramento Regional County Sanitation District (SRCSD) to develop a program of needed facilities and activities to the year 2020. The 2020 Master Plan is providing a focused review of optimization concepts consistent with SRCSD strategic goals. The project involves working with regulators and downstream water agencies through an extensive stakeholder program to develop workable alternatives to meet effluent and receiving water requirements. Activities associated with the 2020 Master Plan include development of an interactive "web-hosted" Master Plan Model, a comprehensive Bufferlands Master Plan, a Biosolids Management Plan, a Competitiveness Guidance Document, initial groundwork on the Environmental Impact Report, and financial/revenue planning.

- Project manager for the development of the $2.2 million SRWTP Strategic Master Plan (1994) which established a program for implementation of $1.5 billion of capital improvements for 350 mgd of wastewater treatment facilities over a 20-year planning period. This Master Plan received the American Academy of Environmental Engineers (AAEE) Engineering Excellence Honor Award and the California Water Environment Association (CWEA) Engineering Achievement Award. This is one of the first plans in the country to address the potential impact of the new federal and California effluent discharge requirements for toxics. The master planning effort included the development of a Toxics Action Plan to implement a cost-effective program for control of TDS, heavy metals, and toxic

organics through increased source control and watershed management. Work involved an evaluation of advanced treatment alternatives for toxic metals, including considering cross-media impacts. A major component of the plan was the development of a flexible water reclamation strategy as a method of avoiding the potentially high cost of continued river discharge in the future. Carollo performed a treatment process evaluation of the existing wastewater treatment facilities, including the pure oxygen activated sludge process and sludge thickening and digestion facilities. Finally, Carollo prepared a financial analysis which evaluated sources and uses of funds and the impact on connection fees and user charges.

- Project manager for the $1.1 million Wastewater Strategic Master Plan for the Cities of Reno, Sparks, and Washoe County, Nevada. The Strategic Plan projects wastewater facility needs through the year 2015 for the existing Truckee Meadows Water Reclamation Facility (TMWRF) and South Truckee Meadows Water Reclamation Facility (STMWRF). The TMWRF must meet some of the most restrictive discharge requirements in the country through advanced wastewater treatment, including biological phosphorous removal. Therefore, a major objective for the Strategic Plan was the analysis of seasonal discharge opportunities in combination with the development reclaimed water projects. The Strategic Plan also evaluated the cost effectiveness of building a second satellite plant, compared to the cost of expanding existing regional treatment facilities. In addition to these major issues, the Strategic Plan also evaluated methods to improve the performance of existing facilities and developed "non-structural" alternatives to reduce nitrogen and TDS loadings to the Truckee River through water conservation, non-point source control, river restoration, and the development of pollutant trading credits. The Strategic Plan included a sophisticated river modeling effort to evaluate the impacts of TDS, nitrogen, and temperature, along with the benefits of storage and seasonal release of river water.

- Project manager for the Integrated Water Resources Plan for Washoe County, Nevada, to determine the best combination of water and wastewater scenarios for the county, which includes the cities of Reno and Sparks. Following the scenario development and evaluation, Carollo prepared a detailed financial analysis of the recommended water and wastewater alternatives.

- Project manager for the $1.7 million Wastewater Strategic Master Plan for the Fresno/Clovis Metropolitan Area. This 25-year Master Plan addresses the wastewater management needs for a projected population of 1.1 million people through the year 2020. Key issues included the evaluation of satellite wastewater treatment plants, package plants, increased treatment for discharge to the San Joaquin River, potential impact of on-site effluent percolation basins on groundwater quality and water reuse for agriculture and community-based uses, and investigation of water conservation and source control methods to reduce wastewater generated and TDS effluent concentrations. The Master Plan developed a recommended Capital Improvement Program (CIP), including a financial analysis of the impact on sewer service rates and charges.

- Project manager for 20-year Wastewater Facilities Master Plans for the West County Wastewater District, California. Key issues addressed included the level of treatment required to meet California Administrative Code Title 22 requirements for water reclamation, advanced treatment levels for continued effluent discharge to the San Francisco Bay, effluent disinfection alternatives, biosolids reuse/disposal, and air emission controls for odors and volatile organic compounds (VOCs).

- Project engineer for the development of a Wastewater Facilities Plan for the Union Sanitary District Alvarado Wastewater Treatment Facilities in Fremont, California. The Facilities Plan evaluated and recommended the best apparent liquid and solids treatment alternatives to treat a design flow of 35 mgd average dry weather flow (ADWF). Key issues addressed included the decision to continue or abandon existing rotating biological contactors (RBCs) for secondary treatment, site constraints which limited the room available for new facilities, optimization of sludge thickening and digestion facilities, and odor control.

- Project manager for development of a Wastewater Master Plan for the City of Benicia, California. The Master Plan developed projected wastewater flows and loads, evaluated alternatives, and developed a phased Capital Improvement Plan (CIP) through the year 2010. Key issues and

processes evaluated included failed RBCs and replacement with the activated sludge process, hypochlorite disinfection, dissolved air flotation thickening, anaerobic digestion, belt press dewatering, and extensive odor control facilities and sound abatement system.

- Assistant project manager for the City of Stockton Recycled Water Market Assessment and Reclamation planning. This project evaluated a wide range of reclamation alternatives for both reducing Stockton's treated wastewater discharge to the San Joaquin River and enhancing Stockton's water supply resources. Alternatives included blending reclaimed water with fresh surface water supplies in surface storage reservoirs such as the East Bay Municipal Utility District's Comanche Reservoir, supplying the water to irrigation districts for agricultural use, groundwater recharge, and community-based irrigation and industrial water reuse. The study included an economic evaluation of primary, secondary, and tertiary benefits of water recycling for each alternative.

- Project manager for development of a Biosolids Management Plan for the City of Palo Alto Regional Water Quality Control Plant (RWQCP). The plan developed recommended facilities required to handle, process, and dispose of wastewater solids through the year 2020. The RWQCP is a tertiary wastewater treatment facility with an ADWF design capacity of 39 mgd. The solids handling evaluation included a capacity assessment and evaluation of two multiple hearth furnaces for sludge incineration. Biosolids alternatives evaluated included continued incineration, anaerobic digestion, indirect heat drying, chemical stabilization, and composting.

- Project manager for a thermal compliance study for the Sacramento Regional County Sanitation District. This study was conducted to satisfy the State Water Resources Control Board and California Department of Fish and Game concerns regarding the potential thermal impact on chinook salmon in the Sacramento River due to the 150-mgd discharge of secondary effluent from the Sacramento Regional Wastewater Treatment Plant (SRWTP). The evaluation of potential impact involved the development of a computerized effluent and river mixing model, and field calibration. Based on the results of the modeling and study, the State Water Resources Control Board granted the SRWTP a conditional exception to the California Thermal Plan requirements.

- Project manager for development of Basis of Design for Emergency Storage Basin (ESB)-D for the Sacramento Regional Wastewater Treatment Plant (SRWTP) to meet California Thermal Plan requirements.

Permitting and Regulatory Compliance

- Project manager for EIR/NPDES Permitting Support for the Sacramento Regional County Sanitation District (SRCSD) to expand the existing plant from 181 million gallons per day (mgd) to 218 mgd and increase discharge to the Sacramento River. Major technical issues addressed included heavy metals and trace organics toxicity in the immediate vicinity of the discharge, mixing zone characterization due to varying river flows and tidal stage, far-field water quality impacts on downstream water purveyors, and thermal compliance concerns related to endangered species. Permitting issues included developing strategies for increasing permit capacity through re-rating of existing facilities to meet expansion schedule concerns.

- Project manager for the permitting of the new 12-mgd Pleasant Grove Creek Wastewater Treatment Plant (PGWTP) for the City of Roseville. The PGWTP is a tertiary treatment plant discharging to an effluent dominated receiving stream. Major issues included impacts on vernal pools and on-site wetlands, impact on ephemeral stream biology, concerns of downstream organic farmers, ability to meet water quality objectives during extreme flow variations (including pH, turbidity, and temperature), and dissolved oxygen. Also, the receiving water is 303(d) listed for mercury. The project involved field sampling design, water quality modeling, scientific investigations of impairment impact, and analysis. Permits successfully obtained include all site development permits, construction permits, a new NPDES permit, and a new air permit.

- Project manager for the NPDES permit renewal of the existing Dry Creek Wastewater Treatment Plant (DCWTP) for the City of Roseville. The DCWTP is an 18-mgd tertiary treatment plant discharging to a cold water fishery (steelhead and

salmonids) which are endangered. Key permitting issues included thermal impacts, toxics, conventional pH, turbidity, and dissolved oxygen.

- Project manager for the Basin Plan Amendment (BPA) for the Central Valley RWQCB, California. This project is funded by a coalition of publicly owned treatment works (POTWs) which discharge to ephemeral streams that are effluent dominated. The coalition is funding the science-based review of the water quality objectives for pH and turbidity to support an amendment to the Basin Plan.

Disinfection

- Project manager for a UV pilot test and feasibility study for the West County Wastewater District in Richmond, California. This was a four-month pilot testing program involving a side-by-side comparison of the performance of a pilot-scale UV system with an existing gaseous chlorine disinfection system. The testing included the evaluation of the required UV dosage to meet a wide range of total and fecal *coliform* standards with and without filtration. The feasibility study compared gaseous chlorine, UV, and sodium hypochlorite disinfection on the basis of cost, reliability, safety, and other considerations. Key issues included the conversion of the existing chlorine contact basin to a UV contactor, alternatives to gaseous chlorine for odor control, and the suitability of UV disinfection for reclaimed water use on an existing golf course.

- Project manager for the Alternative Disinfection Study for East Bay Municipal Utility District's (EBMUD) 90-mgd Wastewater Treatment Plant in Oakland, California. This study involved the determination of the risk to the public due to the use of gaseous chlorine for disinfection and odor control, and the evaluation of alternatives to chlorine. Alternative disinfection methods evaluated as to their feasibility and cost included ultraviolet radiation UV and ozonation. This evaluation and comparison provided the basis for a preliminary facilities layout. Subsequently, served on the Technical Advisory Committee overseeing the UV pilot testing program for EBMUD involving three different equipment manufacturers.

- Project engineer for the preliminary design of an emergency chlorine scrubber facility for the City of Phoenix, Arizona, 91st Avenue Wastewater Treatment Plant. Responsibilities included developing process design criteria and an established sequence of operation and monitoring requirements for containment and scrubber facilities to accommodate a leak rate of 7,000 lb/hr of chlorine from an 18-ton rail car.

- Project manager for the $2.2 million Sacramento Regional Wastewater Treatment Plant (SRWTP) Master Plan. This comprehensive planning effort included identifying and screening a broad range of conceptual disinfection methods. The result was completion of a national survey of existing facilities to further evaluate ozone, ultraviolet radiation, and hypochlorite. Based on this survey and site-specific data, the team established preliminary design criteria for a multi-purpose disinfection contact tank to utilize either chlorine or ozone for disinfection.

Financial/Environmental and Economic Analyses

- Senior project manager for the Asset Condition Assessment study of the Water Pollution Control Plant (WPCP) at the City of Sunnyvale, California. This study was conducted as part of an asset management plan to ensure the City's assets are meeting prescribed level-of-service goals, to decrease the costs and risks associated with plant operation, and to prepare and plan for the future more effectively.

- Partner-in-charge for the Independent Evaluator Services for the Baseline Asset Evaluation for the City of Stockton and OMI/Thames Water. The project involved a condition assessment and asset valuation for privatized operation of municipal water supply, wastewater collection and treatment, and stormwater collection systems.

- Project manager for the City and County of Honolulu's Engineer's Report relating to the issuance of revenue bonds in 1998 to finance capital improvement projects for Honolulu's wastewater system. The bonds will finance a 20-year capital improvement plan.

- Project manager for the determination of financial rates and charges for the Orange County Sanitation District (OCSD). This is a major review and modification of the OCSD rate structure, involving consideration of innovative methods for industrial "incentive" rates and fees. The

identification of areas for improvements in the existing rate structure, and the identification and evaluation of alternative rate structure methods includes monthly workshops with a Rate Advisory Committee (RAC). The RAC members are stakeholders representing the residential, commercial, and industrial user groups.

The key issues currently being addressed through this process include: assessment of additional capacity fees for increased discharges from existing users, allocation of capital and O&M costs to wastewater flow, BOD and TSS, alternative sewer service charges, and capacity fees involving industrial and commercial users, tiered residential user charges and capacity fees, single vs. multi-family equivalencies, alternative connection fee methods for residential users, and others.

- Project manager for a connection fee study for the City and County of San Francisco. This study involved the assessment of a fair and equitable connection fee for an agency which is substantially "built-out." Work involved identifying and developing a number of connection fee methods including considering grant-funded facilities, valuation of existing facilities, estimated "buy-in" costs, and projected cash flow requirements to meet anticipated discharge/treatment requirements.

- Project manager for an economic study of wastewater flow reduction/diversion alternatives for the City of San Jose. The goal of this study was to develop an overall methodology and rationale for a cost-effective, phased implementation schedule of structural and non-structural options for reduction or diversion of effluent flows from the San Jose/Santa Clara Water Pollution Control Plant (SJ/SC WPCP). The California Regional Water Quality Control Board (RWQCB), San Francisco Bay Region, has established a limit on discharge of highly treated wastewater to the San Francisco Bay of 120 mgd average day dry weather flow (ADWF). This economic analysis considered a number of costs and benefits in the ranking of the available options, including avoided cost of new potable water supplies, and value of avoided treatment/diversion. This economic analysis was used as the technical basis for the revised South Bay Action Plan (June 1997) submitted by the City of San Jose Environmental Services Department to the RWQCB.

- Project manager for a review of the East Bay Municipal Utility District's (EBMUD) wastewater rates and charges system in allocating O&M and capital costs to billable constituents and, ultimately, to the customers. The goal of the update was to confirm the equitable allocation of costs to users in light of recent operational changes and plant improvements.

- Project manager for development of a Revenue Program for the Sacramento Regional County Sanitation District (SRCSD). The Revenue Program established the methodology for setting equitable sewer connection fees and sewer service charges based on the "cost of service" principle. In addition, this was the first major Revenue Program to develop innovative "incentive" rates and fees for industrial users. The development of industrial "incentive" fees resulted in significantly reducing industrial connection fees to attract and keep jobs in the SRCSD service area. The recommendations of this study were used to set rates and charges to fund the approximately $52 million operating budget and the $1.2 billion Capital Improvement Program (CIP) for the 150-mgd Sacramento Regional Wastewater Treatment Plant (SRWTP). The study included a series of monthly workshops involving representatives from the industrial, commercial, and residential community. The project included presenting a series of technical memorandums addressing a number of key issues during the workshops. Key issues addressed included: the appropriate measure of oxygen demand to use as a billing parameter, demand charges for seasonal dischargers, allocation of costs to billable constituents, transferability of sewer capacity, increased discharges from existing users, and allocation of costs to replacement, improvement and expansion.

- Project manager for the development of Engineer's Reports accompanying the SRCSD's Financing Authority 1993 and 1995 Revenue Bonds for a combined issuance of approximately $375 million. This project included developing and successfully presenting, to MOODY's and S&P Rating Agencies in New York, a unique financing approach relying heavily on the use of connection fee revenues to fund future facilities; resulting in an "AA" bond rating for both issues.

- Project manager for an integrated financial analysis for the Cities of Reno, Sparks, and Washoe County, Nevada. This analysis was developed to support the Regional Water Planning Commission in their deliberations on the most cost-effective combination of wastewater and water capital improvement projects. Special features of this analysis included the allocation of capital and operations and maintenance costs among the three agencies, development of the method for "leasing" treatment capacity, and the development of a combined wastewater and water rate for ranking the regional water/wastewater alternatives.

- Project manager for the Reno, Sparks, and Washoe County Wastewater Facilities Master Plan and associated financial analysis. This Master Plan developed the basis for the CIP for wastewater facilities through the year 2015. The associated financial analysis included the impact of the recommended CIP expenditures on sewer service charges and connection fees for each of the agencies.

- Project manager for the development of a Wastewater Revenue Program for the City of Sparks, Nevada. This study served as the basis for a new wastewater rate and impact fee ordinance, and involved the development of a line item operating budget and cash flow analysis.

- Project manager for the Fresno/Clovis Master Plan. This Master Plan addresses the wastewater management needs for a projected population of more than one million people through the year 2015, including a financial analysis and rate impact study. The financial analysis involved developing a recommended CIP, including analysis of the impact, on sewer service rates and connection fees, of changes in projected wastewater flows and strength.

- Project manager for development of a wastewater revenue program for the West County Wastewater District (WCWD). This Revenue Program addressed the allocation of capital project costs to replacement, improvement, and expansion, as well as separate allocations for capital and operations and maintenance costs to wastewater flow, BOD, and TSS. Work included developing a cash flow analysis and rate impact assessment.

Wastewater Facilities Design

- Project manager for the design of a $23.5 million Wastewater Treatment Plant Improvement Project for the City of Benicia, California. The project included design of hydraulic improvements, new aeration basins and associated blower and pumping facilities, new secondary clarifiers, a new hypochlorite disinfection system, a new dissolved air flotation thickener (DAFT), a new anaerobic digester, conversion of a floating-cover digester to a fixed-cover digester, new belt filter press dewatering improvements, and a new operations/maintenance building, including laboratory facilities. A key technical consideration was bay mud to a depth of 100 feet under the site, and the impact on the design of structures and support utilities. Key institutional issues included renegotiation of the NPDES permit, mitigation of on-site designated wetlands, an Army Corps of Engineers 404 Permit, and a Section 7 consultation process with the US Fish and Wildlife to address concerns over the endangered clapper rail crane and black crane. This project also included a financial plan, State Revolving Loan funding, and a public involvement program that resulted in a successful 2/3 vote for a GO Bond election.

Watershed Management/TMDL Development

- National Research Council (NRC) "Committee to Assess the TMDL Approach to Water Quality Management." This NRC committee was commissioned at the request of Congress and the USEPA to evaluate the scientific basis for the total maximum daily load (TMDL) approach to watershed management. The charge of the committee was to assess the adequacy and reliability of data and modeling methods available to the states to implement the TMDL program. The committee report was submitted to congress in June 2001. It provides recommendations to the USEPA and Congress on ways to apply the newest scientific approaches and methods available. The EPA is currently revising the proposed TMDL regulations to incorporate the committee's recommendations.

- Project manager for the Watershed Management Plan and development of TMDLs for nutrients (total nitrogen and total phosphorus) and total dissolved solids (TDS) for the Truckee River. The Truckee

River flows from Lake Tahoe, California, to Pyramid Lake, Nevada, and is one of the few lake-to-lake riverine watersheds in the world. The endangered Cui-ui and the Lahontan Cutthroat Trout are major fishery resources of concern. This project involves the development and application of watershed and water quality models including HSPF, DSSAM, and WARMF, in order to establish TMDLs and to evaluate the effectiveness of watershed management alternatives. Structural and non-structural alternatives were developed and assessed to develop an overall watershed management plan. Structural alternatives were evaluated for water and wastewater treatment and water reuse, including advanced biological nutrient removal (BNR) and microfiltration/reverse osmosis. Innovative non-structural management options evaluated included water augmentation, river restoration, septic tank conversions, and water conservation. Innovative pollutant trading strategies were developed working with the Nevada Division of Environmental Protection (NDEP), and the USEPA Region 9. A major coordinated monitoring program was developed and implemented that resulted in 14 federal, state, and local agencies committing resources to obtain the data needed to support the various goals and objectives for water quality modeling, listing/delisting decisions, and other purposes. Stakeholders include all of the major Northern Nevada interests, including the Pyramid Lake Piaute Tribe (PLPT), City of Reno, City of Sparks, Washoe County, NDEP, USEPA, state and federal resource agencies, and others.

- Project manager for the Calleguas Creek Watershed Assessment under the auspices of the Joint Powers Agencies (JPA), a coalition of wastewater and water purveyor agencies in the Calleguas Creek Watershed. This project required the development of a watershed assessment and TMDL for chloride to protect sensitive avocado and strawberry yields. It is one of the first TMDLs in the country to address the linkage of surface and groundwater basins and their interactions. It is also the first TMDL to be established for the protection of agricultural beneficial uses. The evaluation included development of alternatives including advanced wastewater treatment and well-head treatment.

- Project manager for the CALFED/CCWD Rock Slough Water Quality Action Project to evaluate sources of total dissolved solids (TDS), total organic carbon (TOC), and other constituents causing water quality degradation in the Contra Costa Water District (CCWD), California, raw water supply. The project involved extensive field monitoring for flow and water quality constituents, surface water modeling, and analysis. A major component of the project is the public involvement and outreach program to solicit input from stakeholders including farmers, stormwater managers, and private landowners. This project is one of the first in the San Francisco Bay Delta to address water quality degradation from a watershed perspective, and serves as a precedent for anticipated future CALFED program implementation to improve water quality in the Delta.

- Project manager for the study to assess the bioavailability of dissolved organic nitrogen (DON) from the Truckee Meadows Water Reclamation Facility (TMWRF). This project and pilot study involved recruiting a nationally recognized team of engineers and scientists from industry and universities (University of Michigan, University of California-Berkeley), to design a methodology for determining whether the remaining residual DON in the TMWRF effluent was biologically available in the receiving stream. The implications of this research are significant to the proposed nutrient criteria and pending USEPA nutrient regulations.

Odor Control/Air Toxics

- Technical Advisory Group (TAG) consultant leader for the three-year research effort for the Water Environment Research Foundation (WERF) to evaluate the "Control and Production of Toxic Air Emissions by Publicly Owned Treatment Works (POTWs) Odor Control Equipment." (Project Number 91-VOL-2) The purpose of this research was to increase the level of understanding about odor control technology and POTWs on consulting with toxics and ozone precursor emissions by compiling and/or developing information necessary for POTWs to plan, design, modify, and operate odor control equipment. The research was the cooperative effort of the East Bay Municipal Utility District (EBMUD) and the University of California, at Davis. The TAG was composed of air quality experts from 11 POTWs, four universities, nine engineering consulting firms, eight odor control

equipment representatives, and five federal, state, and local regulatory agencies.

- Project manager for the Alternative Disinfection and Odor Study for EBMUD's 90-mgd Wastewater Treatment Plant in Oakland, California. This study involved the determination of the risk to the public due to the use of gaseous chlorine for disinfection and odor control, and the evaluation of alternatives to chlorine. Alternative disinfection methods evaluated as to their feasibility and cost included UV, hypochlorite, and ozonation. This evaluation and comparison provided the basis for a preliminary facilities layout.

- Project engineer for an extensive odor study of two wastewater treatment plants for the Inland Empire Utilities Agency (IEUA) in Rancho Cucamonga, California. The study identified odor sources, evaluated control alternatives, and developed a phased action plan to reduce on-site and off-site odors. Major sources evaluated included trickling filters, raw sewage and primary effluent equalization basins, headworks facilities, primary sedimentation tanks, anaerobic digesters, belt press sludge dewatering, and dissolved air flotation thickeners.

- Project engineer for an air toxics assessment for IEUA. Responsibilities included development of an Air Toxics Emission Inventory Plan (AEIP), development and implementation of a source testing program, and development of an Air Toxics Emission Inventory Report (AEIR). The air toxics assessment also included the preparation of a screening-level health risk assessment to estimate cancer and non-cancer health effects.

- Project manager for the UV disinfection pilot study and alternative disinfection and odor control evaluation for the West County Wastewater District (WCWD). This four-month pilot test and subsequent predesign evaluated the technical feasibility and costs associated with a UV disinfection retrofit of an existing gaseous chlorine disinfection system and alternate methods of odor control. Key issues included the conversion of the existing chlorine contact basin to a UV contactor, alternatives to gaseous chlorine for odor control, and the suitability of UV disinfection for reclaimed water use on an existing golf course.

- Project engineer for an extensive odor study for the Salt Lake City Water Reclamation Plant. This study addressed some unique challenges including how to mitigate odors from large-area services, including more than 12 acres of sewage sludge drying beds. Work included monitoring and prioritizing over 28 potential odor sources for further evaluation and recommended control development. Odor monitoring included measuring hydrogen sulfide, ammonia, and representative air toxic compounds. Control alternatives evaluated included odor "fences," packed tower scrubbers, mist towers, carbon adsorption, and containment covers, among others.

- Project manager for an odor emission study and preliminary design of new odor control facilities for the Encina Water Pollution Control Plant in Carlsbad, California. The study combined in-plant and community odor monitoring with computer modeling to identify plant odor sources, to estimate the degree of odor control required, and to predict the reduction in off-site odors as a result of implementing the odor control recommendations. Major odor sources identified included the headworks/screening room, primary treatment basins, primary effluent channel, return activated sludge channel, belt press sludge dewatering building, and the aeration basins. Control alternatives evaluated included packed tower scrubbers with various oxidizing agents, mist towers, biotowers, carbon adsorption, and purafil adsorption, among others. One of the major recommendations was to cover and control odors off of the primary sedimentation basins and the aeration basins.

- Project manager for an Odor Control Action Plan for the City of Benicia Wastewater Treatment Plant. This evaluation included field measurements and engineering estimates of odorous emissions, evaluation of a wide range of alternatives to control odors, and development of recommended short-term and long-term action plans. The study evaluated odors from the headworks, grit basins, primary sedimentation basins, digesters, sludge thickener, and belt press dewatering facilities. Odor control alternatives evaluated included high performance carbon scrubbing, chemical addition including hydrogen peroxide, and cover and containment.

- Technical advisor for the study and design of odor control improvements for the Thomas E. Piacenti Regional Water Pollution Control Facility in New London, Connecticut. The study and design included odor dispersion modeling and development and evaluation of alternatives to control odors from the plant headworks, primary clarifier effluent weirs, sludge storage tanks, sludge truck fill station, sludge loading bay, and belt press areas to meet a target odor level of 8 D/T at ground level.

- Project manager for the study and subsequent design of odor control improvements to the sludge dewatering building for the City of Santa Rosa's Laguna Wastewater Treatment Plant. This project included developing and designing a unique point source ventilation system to collect high-concentration, low-volume odors (including ammonia levels of up to 300 ppm) from four 2-meter belt filter presses. The design also included a new sweep air system to purge the building using the natural connective air from a direction determined through smoke bomb testing.

- Project manager for the biosolids dewatering pilot study and predesign for the Sacramento Regional County Sanitation District (SRCSD). This project involved the full-scale, side-by-side pilot testing of centrifuges and belt filter press to evaluate dewatering technology, including the potential for odor emissions. Equipment consisted of one-meter Ashbrook Winklepress (fourteen rollers) and a Sharples DS-305 centrifuge. The project involved fully enclosing both pilot-test trailers in plastic with supply fans to control air change rates. Work included analyzing air samples for hydrogen sulfide, methyl mercaptan, ethyl mercaptan and volatile organic compounds (VOCs). The test results provided a basis for developing odor control design criteria.

- Project manager for the $2.2 million Sacramento Regional Wastewater Treatment Plant (SRWTP] Master Plan. This comprehensive planning effort included an evaluation of air pollution control technologies for conventional pollutants, odors, and air toxics.

- Project manager for an air toxics assessment for the West County Wastewater District. (WCWD). The air toxics assessment included preparation of an Air Emission Inventory Plan (AEIR) and an Air Emission Inventory Report (AEIP) to meet the requirements of the Air Toxics Hot Spots and Assessment Act of 1987 (AB 2588). Responsibilities included developing the AEIP and developing/implementing a source testing program to estimate potentially toxic air emissions for various treatment plant processes. The AEIR includes development of process models and ultimately total emission estimates.

- Project engineer for the side-by-side performance test of trailer-mounted sludge dewatering belt presses and centrifuges and associated odor control during the planning phase of a $10 million dewatering systems improvements project for the Central Contra Costa Sanitary District (CCCSD). This project involved using an odor emission study, including measurements of hydrogen sulfide and methyl mercaptan, along with dilution-to-threshold measurements (D/Ts), to characterize odors associated with the pilot dewatering units. The study results were instrumental in the decision to choose centrifuges over belt presses, and were later used to help establish odor control design criteria.

- Project engineer for the design of odor control for a sludge "thickener" operating as a storage and surge tank for raw sludge for CCCSD. The odor survey and analysis provided a basis for the design of a packed bed counter-current scrubber for 98 percent removal of 6,000 cfm of foul air containing 100 ppm of hydrogen sulfide. The scrubbing agent was sodium hypochlorite.

- Project manager for a side-by-side performance test and engineering assessment of a packed tower counter-current scrubber and a proprietary mist tower for CCCSD. Test results were used to recommend the best method of controlling raw sludge odors.

- Project manager for a screening-level and a formal human health risk assessment (HRA) for CCCSD's 45-dry-ton-per-day sewage sludge incineration operation. The project also included an evaluation of odor potential. The HRAs were conducted in conformance with the California Air Pollution Control Officers Association (CAPCOA) Risk Assessment Manual and in conformance with the pending USEPA sewage sludge technical regulations (40 CFR Part 503). An understanding of HRAs in developing alternatives for odor control is becoming increasingly important because controlled

and uncontrolled odor emissions (including chlorine carry-through) are required to be included in the toxics emissions inventory data under the California Toxics Air Hot Spots Act (AB 2588).

- Project manager for development of a Biosolids Management Plan for the City of Palo Alto Regional Water Quality Control Plant (RWQCP). The plan recommended facilities to handle, process, and dispose of wastewater solids through the year 2020. The RWQCP is a tertiary wastewater treatment facility with an average dry weather flow (ADWF) design capacity of 39 mgd. The solids handling evaluation included a capacity assessment and evaluation of two multiple hearth furnaces for sludge incineration. Biosolids alternatives evaluated included continued incineration, anaerobic digestion, indirect heat drying, chemical stabilization, and composting.

Biosolids

- Project manager for the biosolids dewatering pilot study and predesign for the Sacramento Regional County Sanitation District (SRCSD). This project involved the full-scale, side-by-side pilot testing of centrifuges and belt filter press dewatering technology, and completion of preliminary design for full-scale dewatering facilities. Equipment consisted of one-meter Ashbrook Winklepress (fourteen rollers) and a Sharples DS-305 centrifuge. The pilot test compared process performance of the two dewatering technologies on both digested biosolids, and harvested biosolids from SRCSD's on-site solids storage basins. Key design considerations addressed included reduction of struvite formation, compatibility with a wide range of biosolids reuse/disposal options, odor control, and flexibility to dewater either digested or harvested biosolids.

- Project manager for development of a Biosolids Management Plan for the City of Palo Alto Regional Water Quality Control Plant (RWQCP). The plan recommended facilities to handle, process, and dispose of wastewater solids through the year 2020. The RWQCP is a tertiary wastewater treatment facility with an average dry weather flow (ADWF) design capacity of 39 mgd. The solids handling evaluation included a capacity assessment and evaluation of two multiple hearth furnaces for sludge incineration. Biosolids alternatives evaluated included continued incineration, anaerobic digestion, indirect heat drying, chemical stabilization, and composting.

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Previous Experience

Mr. McDonald served as senior engineer in the Design and Planning Divisions for the Central Contra Costa Sanitary District (CCCSD). Responsibilities included planning for all treatment plant capital project improvements, including serving as project manager for significant solids and liquids handling/treatment systems from the planning stage through laboratory and full-scale pilot plant testing, design, and construction. Specific experience includes:

- Project manager for the preparation of a 30-year Wastewater Treatment Plant Master Plan for CCCSD (through the year 2020). This planning

effort included an assessment of existing facilities, projection of the "buildout" treatment requirements, development, analysis, and recommendation of the best apparent alternative to meet future flows and regulatory requirements. This project included extensive discussions with the State and Regional Water Quality Control Boards (SWRCB, RWQCB), Bay Area Air Quality Management District (BAAQMD), California Department of Fish and Game, and county and local governments.

- Project manager for the development of a Solids Facilities Plan for CCCSD involving incineration. This effort required conducting a human health risk assessment of the existing sewage sludge incinerator operation. The project required a thorough understanding of the proposed USEPA sludge technical regulations (40 CFR Part 503) as well as recent California Air Pollution regulations containing risk-based standards. The project objective was to evaluate the existing practice of sludge incineration, to develop alternatives to incineration (e.g., digestion), and to recommend the most cost-effective facilities for future needs.

- Project manager for the preparation of a Liquids Treatment Facilities Plan for the development of a Wet Weather Management Plan for CCCSD and RWQCB concurrence. This planning study included the development of the most cost-effective combination of treatment versus storage facilities to handle peak wet weather flows. Key issues addressed in this study included receiving water assimilation of toxics and dilution requirements. Also considered and evaluated was a new wet weather discharge permit to Walnut Creek. A Local Effects Monitoring (LEM) program was designed and implemented. A stream sampling program was developed and background pollutant data used in evaluating the potential impact of an infrequent discharge of partially treated effluent at different stream flows and velocities.

- Project manager for the metals balance and investigation of unit operation removal efficiencies of the primary, secondary, and incineration processes. The purpose of this study was to establish compliance with the toxic discharge requirements of the San Francisco Regional Water Quality Control Board Basin Plan and to improve the secondary water quality delivered to the water reclamation filtration facilities. This study was also used to help establish local limits under the National Pretreatment Program.

- Project manager for a pilot plant study incorporating side-stream biological phosphorous removal for the CCCSD Water Reclamation Plant. The CCCSD plant was designed for water reclamation involving high-lime addition to primary sedimentation for phosphorus removal, single-stage nitrifying activated sludge, biological denitrification with methanol addition, disinfection, and effluent filtration. Removal of phosphorus using the biological process was investigated to evaluate and compare performance and cost with removal of phosphorus by lime addition. The purpose of the pilot study was to establish design criteria and operating parameters for a full-scale biological phosphorous removal system. Responsible for the design of a 5-gpm pilot plant with all unit operations, including a phosphorous stripper tank to simulate full-scale performance. Design criteria were established for detention times, aspect ratios, and removal rates. The pilot plant study demonstrated the ability of the biological process to consistently produce finished water quality with less than 1 mg/l of total phosphorus.

- Project engineer for the pilot plant study to test the ability of a proprietary ion exchange resin to simultaneously remove phosphorus nitrates and selected heavy metals for the joint Contra Costa Water District/CCCSD ion exchange facility. This study involved the investigation of a new ion exchange resin capable of operating at an intermediate pH necessary for the efficient removal of both phosphorus and nitrates. The purpose of the pilot program was to determine the optimum feed rate, backwash interval, and time to break-through for the resin.

- Project manager for modifications to CCCSD's lime feed system to the primary clarifiers. CCCSD's treatment plant was designed as an advanced physical-chemical wastewater reclamation plant, with high-lime to primaries for removal of phosphorous and selected heavy metals, and for pH conditioning prior to nitrification/denitrification. Modifications included design of new lime slakes and pneumatic delivery systems.

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FINAL PROJECT MEMORANDUM

Project Name:	SRWTP Advanced Treatment Cost Updates	**Date:**	September 30, 2010
Client:	SRCSD	**Project No:**	7084B.00
Prepared By:	Steve McDonald		
Reviewed By:	Elisa Garvey, B. Narayanan		
Subject:	Comments on the nitrate and ammonia effluent limit in the SRWTP Tentative Order R5-2010 (September 3, 2010)		
Distribution:	Bob Seyfried, Vyomini Pandya		

PURPOSE

The purpose of this memorandum is to comment on the ammonia and nitrate nitrogen effluent limits in the SRWTP Tentative Order R5-2010 (September 3, 2010) (Tentative Order). The Tentative Order includes monthly average and maximum day ammonia nitrogen effluent concentration limits of 1.8 mg/L (as N) and 2.2 mg/L (as N), respectively. The Tentative Order includes a monthly average nitrate effluent concentration limit of 0.26 mg/L (as N).

BACKGROUND

The "Advanced Treatment Alternatives for the Sacramento Regional Wastewater Treatment Plant" Technical Memorandum (Carollo, March 2009), developed effluent concentrations for five treatment trains (A through E). Treatment Train B estimated final effluent concentrations for an advanced treatment train alternative that includes nitrifying trickling filters (NTFs) and fluidized bed reactors (FBRs) to achieve nitrification and denitrification, respectively.

The Carollo (March 2009) Technical Memorandum is also referenced in the Memorandum titled "Analysis of Costs and Benefits of Advanced Treatment Alternatives for the Sacramento Regional Wastewater Treatment Plant", (Larry Walker Associates, May 2010).

It is important to note that the effluent concentrations estimated in the Carollo (March 2009) Technical Memorandum were for comparing relative pollutant reductions that might be achieved for a wide range of pollutants among the five different treatment alternatives (A through E). Further, these estimated effluent concentrations were based on a simple averaging of recorded SRWTP effluent values and the application of planning-level pollutant reductions, as described below. They should not be used as a basis for establishing effluent limitations for different averaging periods, and for processes for which pilot testing and confirmation of performance have not been performed.

EXHIBIT B

OVERALL APPROACH TO ESTIMATING EFFLUENT CONCENTRATIONS

The overall approach to estimating final effluent concentrations In the Carollo (March 2009) Technical Memorandum, was to apply theoretical pollutant removal efficiencies associated with advanced treatment processes to the historically recorded SRWTP secondary effluent concentrations.

In Carollo (2009), secondary effluent mean concentrations and standard deviations for a range of pollutants were calculated based on SRWTP effluent data from June 2005 through July 2008. The mean and standard deviations were calculated based recorded data from June 2005 through July 2008, and therefore represent the mean and standard deviation recorded over a three-year averaging period.

Removal efficiencies for the different advanced treatment process train alternatives were estimated based on peer reviewed academic and professional journal articles, presentations from professional conferences, published and unpublished pilot plant data, available data from other treatment plants, treatment process manufacturers, and standard textbook references.

Given the wide range of values obtained from the diverse technical sources, best professional judgment was used to select pollutant reduction values for the planning-level purpose of comparing the relative performance of the alternative advanced treatment trains.

These planning-level pollutant reduction values were then applied to the mean SRWTP secondary effluent concentrations to predict final effluent ammonia and nitrate concentrations (among other pollutants) for the alternative advanced treatment trains over the same three-year averaging period. The existing process at SRWTP produces low nitrate concentrations due to the fact that the treatment process is not designed to achieve nitrification. With the implementation of NTFs, the nitrate concentrations in the NTF effluent would be greater than the concentrations in the effluent of the existing secondary treatment process, and this was accounted for in the estimated final effluent from the FBRs.

The resulting ammonia and nitrate concentrations estimated for Treatment Train B were 1.5 mg/L (as N) and 0.26 mg/L (as N), respectively, averaged over the entire data period.

As stated in the Carollo (2009) Technical Memorandum (Section 2, pg. 4), the estimated final effluent concentrations for the alternative advanced treatment trains were developed for planning purposes only. In addition, the Carollo (2009) Technical Memorandum states that additional pilot scale studies would be need to be performed to establish pollutant removal efficiencies for final design criteria should any of these advanced treatment processes actually be required and implemented for SRWTP. This is because the planning-level evaluation in the

Carollo (2009) Technical Memorandum did not consider influent and effluent variability, averaging periods, and other site-specific performance considerations.

DISCUSSION

Section IV.C.3.d.xx. (c) of the Fact Sheet (Attachment F, pg. F-71) of the Tentative Order, includes the following statements regarding the development of the ammonia and nitrate nitrogen effluent limitations:

> *This Order contains a final average monthly effluent limitation (AMEL) and maximum daily effluent limitation (MDEL) for ammonia of 1.8 µg/L and 2.2 µg/L, respectively, based on the NAWQC ammonia criteria for aquatic toxicity with no dilution credit.*
>
> *The removal of nitrate and nitrite (i.e., denitrification) is technologically feasible and is often used at POTWs. Therefore, due to the concerns of adverse effects to aquatic life from nitrogen this Order requires the wastewater is fully denitrified. An average monthly effluent limit of 0.26 mg/L for nitrate (as nitrogen) is included in this Order. This is based on the Discharger's study prepared by Larry Walker Associates, titled, "Technical Memorandum: Analysis of Costs and Benefits of Advanced Treatment Alternatives for the Sacramento Regional Wastewater Treatment Plant," dated May 2010.*
>
> *(Note: Underlining added for emphasis. Also, it is assumed that AMEL and MDEL limits were inadvertently labeled in ug/L instead of mg/L as noted in Table E-6 Effluent Limitations on page 13 of the Tentative Order).*

As can be seen in the citation from the Tentative Permit, the monthly average nitrate effluent limit is based on the requirement of full denitrification, and the Larry Walker Associates (2010) technical memorandum (and Carollo (2009) Technical Memorandum) is cited as the basis for establishing an average monthly effluent limit of 0.26 mg/L (as N).

The average monthly effluent limit of 0.26 mg/L for nitrate (as nitrogen) may not be technically feasible for SRWTP, and the estimated final effluent concentration for Treatment Train B as reported in Larry Walker Associates (2010), and developed in the Carollo (2009) Technical Memorandum, is not an appropriate reference for establishing effluent limits. The reasons for this follow:

- The purpose of the Carollo (2009) Technical Memorandum was to perform a planning-level comparison of the relative performance of alternative advanced treatment trains. As explained, the approach to estimating final effluent concentrations was to use a three-

year averaging period and theoretical and literature value pollutant reductions for advanced treatment technologies. There is no mention in Carollo (2009) of establishing an appropriate effluent concentration limit for permitting purpose. Therefore, the Tentative Order adopted a nitrate effluent concentration limit based on a planning-level study that was developed for a different purpose.

- The Carollo (2009) Technical Memorandum states that the estimated final effluent concentrations were developed for planning purposes only, and that pilot studies would need to be performed to refine treatment process performance. This is due to, as stated in the Carollo (2009) Technical Memorandum, the wide variability in the information and data found in the literature and from other sources regarding pollutant reduction efficiencies. Therefore, the approach of estimating final effluent concentrations using removal efficiencies is an approximate approach, suitable for planning level analyses, but not for predicting effluent concentrations achievable on a consistent and reliable basis. In the absence of more detailed site-specific information and pilot data, best professional judgment was used in selecting pollutant reduction values for the purpose of completing a planning-level study to compare relative long-term pollutant loadings to the River. The source of the pollutant reduction values was not based on site-specific SRWTP considerations, nor was the application of best professional judgment based on comparing maximum effluent concentrations, or for developing final effluent permit limit concentrations for monthly and daily averaging periods.
- The average effluent concentration as reported in the Carollo (2009) Technical Memorandum is not the same as the effluent "not to exceed" concentration. This is a different point than the selection of an appropriate averaging period. Instead, the Carollo (2009) Technical Memorandum was based on best professional judgment in selecting pollutant reductions for comparing the relative average performance over a three-year period among the alternatives, and was not based on establishing a "not to exceed" effluent concentration over different (and shorter) averaging periods which typically exhibit greater variability.
- As noted, the 0.26 mg/L (as N) estimated final effluent concentration was based on applying an estimated pollutant removal efficiency to a secondary effluent mean concentration (with consideration of the change in nitrate concentrations due to implementing nitrification) from a three-year data averaging period. Not only is this approach an approximate one suitable only for planning-level analyses, the estimated final effluent concentration does not include any consideration for what can reasonably be achieved using a different averaging period, such as for a monthly or daily basis. Therefore, the use of a three-year average estimated final effluent concentration of 0.26 mg/L nitrate (as N) is not an appropriate basis for establishing a monthly average final effluent concentration.

CONCLUSION

The average monthly effluent limit of 0.26 mg/L SRWTP for nitrate (as nitrogen) included in the RWQCB Tentative Order R5-2010 (September 3, 2010) may not be technically feasible for SRWTP, and the estimated final effluent concentration for Treatment Train B as reported in Larry Walker Associates (2010), and developed in the Carollo (2009) Technical Memorandum, is not an appropriate reference for establishing this or any other effluent limits for the following reasons:

- The purpose of the Carollo (2009) Technical Memorandum was to perform a planning-level comparison of the relative performance of alternative advanced treatment trains.
- The purpose of the Carollo (2009) Technical Memorandum did not include establishing an appropriate effluent concentration limit for permitting purposes.
- The Carollo (2009) Technical Memorandum states that the estimated final effluent concentrations were developed for planning purposes only, and that pilot studies would need to be performed to refine treatment process performance. The estimation of final effluent concentrations were not based on site-specific SRWTP considerations, nor for developing final effluent permit limit concentrations for monthly and daily averaging periods.
- The average effluent concentration as reported in the Carollo (2009) Technical Memorandum is not the same as the effluent "not to exceed" concentration.
- The 0.26 mg/L (as N) estimated final effluent concentration based on a three-year data averaging period. The estimated final effluent concentration does not include any consideration for what can reasonably be achieved using a different averaging period, such as for a monthly or daily basis.

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FINAL PROJECT MEMORANDUM

Project Name:	SRWTP Advanced Treatment Cost Updates	**Date:**	September 28, 2010
Client:	SRCSD	**Project No.**	7084B.00
Prepared By:	Elisa Garvey		
Reviewed By:	Steve McDonald		
Subject:	Responses to PG Environmental, LLC comments on the "*Advanced Treatment Alternatives for the Sacramento Regional Wastewater Treatment Plant*", (Carollo Engineers, March 2009).		
Distribution:	Bob Seyfried, Vyomini Pandya		

PURPOSE

PG Environmental, LLC prepared a "Technical Review of Estimated Costs for Proposed Changes to the Sacramento Regional Wastewater Treatment Plant" (August 18, 2010) (Technical Review) of the technical memorandum prepared by Carollo Engineers titled "Advanced Treatment Alternatives for the Sacramento Regional Wastewater Treatment Plant" (March, 2009) (Advanced Treatment Alternatives Memo). The Technical Review included comments on the treatment trains, and suggested modifications to some of the treatment trains. The purpose of this project memorandum is to provide additional clarifications, responses to the comments, and to provide comments on the proposed treatment train modifications included in the Technical Review.

BACKGROUND

The Advanced Treatment Alternatives Memo includes estimated capital and operations and maintenance costs (O&M) and estimated reductions of target pollutant for five different treatment trains at a planning-level of analysis. The treatment trains included addition of new treatment technologies to the existing secondary treatment processes at the Sacramento Regional Wastewater Treatment Plant (SRWTP). The target pollutants included: biochemical oxygen demand (BOD); total suspended solids (TSS); total dissolved solids (TDS); total organic carbon (TOC); ammonia-nitrogen; nitrate-nitrogen; total Kjeldahl nitrogen (TKN); total phosphorus; total recoverable copper; total mercury; and trace organic compounds, including endocrine disrupting compounds (EDCs), and pharmaceuticals and personal care products (PPCPs).

The following five treatment trains were developed and evaluated:

- **Treatment Train A (Title 22 Treatment) - Microfiltration (MF) and UV Disinfection (UV):** The treatment rationale was to implement treatment that will produce treated

EXHIBIT C

effluent that meets Title 22 standards and provides for multiple water reuse opportunities of SRWTP's entire flow. In order to implement this train,

- **Treatment Train B (Nutrient Reduction) - Nitrifying Trickling Filters (NTF), Fluidized Bed Reactors (FBR), and Chlorine Disinfection:** The treatment rationale was to significantly reduce nutrients in SRWTP's entire flow in response to potential concerns raised regarding nutrient loading in the Sacramento-San Joaquin Delta.
- **Treatment Train C (Nutrient Reduction + Title 22 Treatment) - Nitrifying Trickling Filters, Fluidized Bed Reactors, Microfiltration and UV Disinfection:** The treatment rationale was to produce treated effluent that meets Title 22 standards and provides for multiple water reuse opportunities of SRWTP's entire flow, and significantly reduces nutrients in SRWTP's entire effluent flow in response to potential concerns raised regarding nutrient loading in the Sacramento-San Joaquin Delta.
- **Treatment Train D ("No Net Increase") - Microfiltration, Reverse Osmosis (RO), and Ozone/Peroxide (Partial Flow):** The treatment rationale was to produce "no net increase" in loading of pollutants to the Sacramento River resulting from a 218 mgd (ADWF) discharge as compared to a 181 mgd (ADWF) discharge for use in the SRCSD's Antidegradation Analysis. Ozone/peroxide, in conjunction with RO, was added to the treatment train as these two processes provide multiple barriers of protection for the removal of trace organics.
- **Treatment Train E (Full RO and Ozonation) - Microfiltration, Reverse Osmosis, and Ozone/Peroxide:** The treatment train rationale was to apply the "no net increase" treatment train to the entire flow of the SRWTP.

These treatment trains were developed in March 2009, and at that time there was limited information on which of the target pollutants would be the driver for advanced treatment at the SRWTP. Therefore, the approach was to develop a series of treatment trains that were designed to remove different pollutants or combinations of pollutants to achieve different levels of effluent quality. The different levels of effluent quality were based on a range of possible future NPDES permit requirements for the SRWTP.

In contrast to the Advanced Treatment Alternatives Memo, the Technical Review prepared by PG Environmental, LLC focused on the ability of all treatment trains to produce effluent that meets CDPH requirements for pathogen removal, a nitrate limit of 10 mg/L (as N) and an ammonia limit of 1.8 mg/L (as N). Therefore, several of the issues raised in the Technical Review are explained by the differences in the original planning basis for developing the proposed treatment trains, as compared to the basis for evaluating the treatment trains in the Technical Review.

RESPONSES TO COMMENTS

The Technical Review includes comments throughout the document, specific comments on each of the treatment trains, and proposed modifications to Treatment Trains C and E. This section includes responses to the review comments as well as the proposed modifications to Treatment Trains C and E.

General

In general, the Technical Review includes critique of the costs developed in the Advanced Treatment Alternatives Memo, and includes proposed modifications to treatment trains on the basis of providing similar levels of treatment at lower capital costs. However, the Technical Review does not include estimated O&M costs associated with these proposed modified treatment trains and therefore does not provide an appropriate basis for comparison. The selection of any advanced treatment facility would need to consider the total life cycle costs that include capital and O&M costs.

Also, a review of the performance of the Modified Treatment Trains C and E compared to the performance of those in the Advanced Treatment Memo was not made in the Technical Review by PG Environmental. This performance comparison is important before an "equivalency" determination could be made.

Section II.A

Comment: *It is uncertain, which Treatment Train cost estimates are base on Class 5 versus Class 4.*

Response: The treatment trains that were developed consist, for the most part, of unit operations that are considered "advanced" in the wastewater industry relative to conventional secondary treatment processes. In addition, few of the advanced treatment trains identified have been constructed and operated at the scale of the SRWTP for a significant period of time. There are some unit operations, however, for which significant experience exists. This includes wastewater pump stations, chlorine disinfection, and UV disinfection. This experience was factored into the overall estimating contingencies when one or more of the unit operations were combined to create the overall treatment trains. Therefore, to clarify, the estimated costs developed for the combined treatment trains in the Advanced Treatment Alternative Memo are to be considered Class 5 estimates as described by the Association for the Advancement of Cost Engineering International (AACEI).

Section III

Comment: *Treatment Train E is the most costly and is not considered to be a cost-effective approach when considering the likely NPDES permit requirements.*

Response: At the time when Treatment Train E was developed, there was no information available on the future NPDES permit requirements for the SRWTP. Treatment Train E was designed to expand the concept of "no net increase" under Treatment Alternative D by treating the projected 218 mgd future flow to provide removal of all target pollutants, including TDS. Also, each of the five treatment trains were planned based on an assumed range of pollutant reduction requirements, as the "likely NPDES permit requirements" were unknown at that time.

Section IV. A.

Comment: *A major limitation in the performance of Treatment Train A is that it does not address the removal of inorganic nitrogen. Most ammonia will be converted to nitrate and be discharged as a nitrate loading. However it does treat the effluent to inactivate coliform bacteria and protozoan pathogens.*

Response: Treatment Train A was designed to produce treated effluent to meet Title 22 standards and to provide for multiple water reuse opportunities of SRWTP's entire flow. Title 22 standards do not require additional removal of inorganic nitrogen (beyond conventional secondary treatment), and therefore nutrient removal processes were not included in Treatment Train A.

Section IV. B.

Comment: *Treatment Train B does not address the issues associated with protozoan pathogens, although some removal of these microorganisms can occur in the biological nitrification and denitrification processes. Biofilters develop biological-growth that produces polymers. These slim growths act as adsorbents, capturing and retaining colloidal and soluble contaminants, but the efficiency of removal for microorganisms is low and variable. Treatment Train B also has limitations on the ability to achieve significant reduction of coliform bacteria, since there is no filtration to improve suspended solids removal. It does not appear that Treatment Train B will be able to consistently meet DPH recommendations.*

Response: Treatment Train B was designed to significantly reduce nutrients in SRWTP's effluent in response to potential concerns raised regarding nutrient loading in the Sacramento-San Joaquin Delta. This treatment train would produce effluent that would be discharged to the Sacramento-San Joaquin Delta (river discharge) as currently practiced. Treatment Train B was not designed to produce effluent quality that meets CDPH Title 22 standards for reuse. Therefore, the comments regarding removal of pathogens and consistent attainment of DPH recommendations are correct, since Treatment Train B was designed to significantly reduce nutrients only.

Section IV. C.

This section includes several comments on Treatment Train C. These comments are addressed separately below.

Comment: *A savings of approximately $260,000 in capital costs can be realized by replacing the UV Disinfection with Ozone/Peroxide Oxidation treatment (a chemical oxidation process). The Ozone/Peroxide Oxidation capital and O&M costs are roughly half of the costs for UV Disinfection. Ozone/Peroxide oxidation is effective for destroying the protozoan pathogens as well as various organic chemicals. Priority pollutants and other "chemicals of concern" (e.g., endocrine blockers) can be destroyed by oxidation given the proper ozone-peroxide dose and contact time. The ability to inactivate these compounds is only a function of chemical oxidant concentration and contact time. This process could be easily modified to address destruction of these compounds if future permits requirements are propagated for their removal.*

Response: Treatment Train C was designed to produce treated effluent that meets Title 22 standards and provides for multiple water reuse opportunities of SRWTP's entire flow, and significantly reduces nutrients in SRWTP's entire effluent flow in response to potential concerns raised regarding nutrient loading in the Sacramento-San Joaquin Delta.

The comment suggests replacing the UV system with an ozone peroxide system because the reported costs are significantly less for ozone peroxide than for a UV system. However, there are several issues with this proposed change:

- A non-proprietary ozonation system is not a CDPH approved disinfection technology under Title 22. Therefore, to meet Title 22 requirements for unrestricted reuse, SRCSD would need to demonstrate effectiveness of this process to obtain CDPH approval. Note that there is a proprietary ozone reactor that has been CDPH approved, but this reactor is designed for small systems.
- The comment suggests that UV can be replaced with ozone/peroxide oxidation at a lower cost without sacrificing treatment efficacy. We agree that an ozone peroxide system can be effectively designed to destroy pathogens and some trace organics. However, one important factor in the selection of UV disinfection was that it is CDPH approved for Title 22 water reuse, and attainment of Title 22 water reuse was an objective of treatment Train C.
- The project cost estimates for ozone/peroxide were developed in the context of Treatment Trains D and E, instead of Treatment Train C. In both Treatment Trains D and E the ozone peroxide process is preceded by reverse osmosis (RO). As noted in Appendix A (Table A17) of the Advanced Treatment Alternatives Memo (Carollo, March 2009), the assumed ozone dose for Treatment Trains D and E is 1 mg/L. This dose is similar to the doses used by Delta drinking water utilities for intermediate oxidation, and

assumes that the RO effluent would have a very low ozone demand. The required ozone dose significantly affects an ozone system project cost estimate. In the proposed modification to Treatment Train C, ozone peroxide would be preceded by media filtration instead of RO. This assumption of the use of media filtration is a concern at this level of planning given that the SRWTP is a high purity oxygen activated sludge (HPOAS) plant. The HPOAS process is associated with effluent variations that are site-specific and highly dependent on influent wastewater characteristics. The recommended approach to confirming the use of media filtration in satisfying the proposed requirements, and to establish design and sizing criteria, would be to perform pilot testing and a feasibility study. At this level of planning it is appropriate to assume a preliminary ozone dose in the range of 8 to 15 mg/L for ozonation of wastewater that is preceded by HPOAS and media filtration At this higher dose range, the project cost for ozonation would be comparable to, or greater than, a UV system. In addition, in the Technical Review the basis for costs are limited to capital costs. As noted previously, the selection of any advanced treatment process would need to consider the total life cycle costs that include capital and O&M costs.

In general, however, the comment of replacing UV with ozone/peroxide raises a valid issue. In any treatment train that SRCSD considers that includes replacement of the existing chlorination process with an alternative disinfection process, then a more detailed evaluation of disinfection alternatives, including UV, ozone and ozone/peroxide, would be conducted. This evaluation would consider that the SRWTP is a HPOAS plant and that there are existing facilities that provide an oxygen source, potentially reducing the cost of ozonation. In addition, evaluation would include pilot testing of these treatment processes to determine required UV doses and required ozone doses, as both of these parameters significantly affect performance and cost. However, the initial selection of UV for the purpose of disinfection was based on a level of evaluation that is consistent with a planning level analysis. The more detailed evaluation of disinfection alternatives should be conducted as part of future work if a change in the disinfection process at the SRWTP were to be considered.

Comment: *The MF process represents a very significant portion of the advanced treatment costs. The MF process is 55.1 percent of the total cost ($161 million of $292 million; from Table 4, page 14 of Carollo 2009 Report). The Carollo 2009 Report, appendix page APP-1, notes that SRCSD has performed pilot testing of MF and it was proven to be an effective advanced treatment for SRWTP's secondary effluent*[1]

1. *Note that the pilot testing data could have been used by SRCSD to provide a more refined cost estimate than a Class 5 estimate.*

Response: While pilot testing was conducted for SRTWP involving a pilot MF unit, it was intended for the purpose of comparing effluent quality to conventional sand filtration, and for producing high quality effluent for assessing the impact on final effluent quality for the design of alternative disinfection systems, but not on flux rates and other design parameters for sizing MF facilities. The AACE International Recommended Practices and Standards states that for a Class 5 estimate the level of project definition is 0 to 1%, while for a Class 4 estimate the level of project definition is 1 to 15%. Therefore, a Class 5 estimate is the appropriate level of definition at this time for the design of a full-scale MF system for SRWTP.

Comment: *There are four alternatives to Treatment Train C that, through implementation of one or some combination of these alternatives, the SRWTP may achieve the same effluent goals at a reduced cost.*

1. *Evaluate other filtration processes such as sand filters and mixed media filters to replace MF, with the goal of reducing total cost.*

2. *The UV Disinfection can be replaced with Ozone/Peroxide Oxidation. The Ozone/Peroxide Oxidation capital and O&M costs are expected to be approximately half of the costs of UV Disinfection. Another important aspect is that simple modifications to the operation, such as increasing ozone-peroxide concentrations, could result in improved removal of "chemicals of concern" in the effluent.*

3. *Evaluate low-cost modifications that can be made to the inlet and outlet structures of the secondary settling tanks to improve removal of suspended solids, colloidal material, and soluble organic compounds. Such options could include physical modifications to provide more appropriate hydrodynamics for good floc growth prior to the secondary sedimentation process.*

4. *Operational changes could be evaluated for improving the existing performance of secondary settling. These could enhance the removal of suspended particles and Cryptosporidium oocysts. This would include testing of various chemical coagulants, polymers, chemical oxidants, and pH levels to improve removal of suspended solids and Cryptosporidium oocysts.*

Response: Responses to the four comments presented above are addressed in order as follows.

1. Other filtration processes, including sand filtration and mixed media filtration, were considered in the development of Treatment Train C. We agree that conventional filtration followed by disinfection is an effective approach for meeting Title 22 standards

today, but not for the high-purity oxygen activated sludge (HPOAS) process used by SRTWP. The HPOAS process used by SRWTP is challenging in terms of capture of pin floc with conventional sand filtration performance. In fact, pilot testing at SRWTP of conventional sand filtration and MF, it was found that MF more consistently met Title 22 requirements.

2. This comment was addressed previously, where it was noted that the project cost of the ozone peroxide system was based on the costs presented for Treatment Trains D and E, where ozonation would be preceded by RO and therefore a lower ozone dose was assumed based on the low ozone demand expected in RO effluent water. At a higher ozone dose range, the project cost for ozonation would be comparable to, or greater than, a UV system.

3. The objectives of the Advanced Treatment Alternatives Memo did not include investigation of modifications to the existing treatment process that would potentially improve suspended solids removal because of the uncertainty of these kinds of improvements to reliably meet the levels of treatment and pollutant reductions required. In general, the further development of any of the advanced treatment alternatives would also include investigation into modifications of existing facilities in combination with new facilities that would potentially improve existing performance or would impact the selection or performance of advanced treatment processes.

4. The SRCSD runs a well managed and operated secondary treatment plant with adequate secondary settling capacity. While operational improvements are always worth investigation, the anticipated improvements in the removal of suspended solids with operational changes alone are not considered sufficient, by themselves, in reliably meeting the assumed range of future discharge requirements in the Advanced Treatment Alternatives Memo. Specifically, there are unique challenges in achieving significant improvements in the suspended solids reductions from the existing secondary treatment process employing the high-purity oxygen activated sludge. In addition, the SRWTP is continuously evaluating how operation changes could improve performance and reliability. Further development of any of the advanced treatment alternatives would also investigate operational changes that would potentially improve existing performance or would impact the selection or performance of advanced treatment processes.

Section IV. D.

Comment: *These advanced treatment processes will reduce coliform and pathogenic protozoan. However, the effluent from the advanced treatment would be blended with the remaining secondary effluent. The blended final effluent would not be expected to meet the DPH*

recommendations. As a result, this treatment train does not achieve any of the objectives of significant nutrient removal or requirements for coliform and pathogenic protozoan. Further, treating only a portion of the total SRWTP flow may constitute bypassing, and SRCSD has withdrawn its request for an increase in flow capacity. Therefore, this alternative was eliminated from further consideration.

Response: Treatment Train D was designed to produce a "no net increase" in loading of pollutants to the Sacramento River resulting from a 218 mgd (ADWF) discharge as compared to a 181 mgd (ADWF) discharge for use in the SRCSD's Antidegradation Analysis. The result of Treatment Train D would be to keep the future mass loadings of target pollutants to the Sacramento River at 218 mgd to no greater than the mass loadings at today's permitted 181 mgd discharge. It is assumed that only a portion of the SRWTP's entire flow at 218 mgd would require additional treatment, and this treated flow would be blended with effluent not receiving such additional treatment to achieve "no net increase" in loadings. This treatment train was developed based on the assumption of continued discharge to the Sacramento River and the concept of providing "no net increase" in loadings. It was not designed to meet more stringent nutrient or pathogen removal requirements although these would be significantly removed from the incremental flow above 181 mgd.

Section IV. E.

Comment: *The MF and RO processes are not nearly as cost effective for ammonia and nitrate removal as the biological processes proposed in Treatment Trains B and C…*

From a cost standpoint, Treatment Train E is not the most cost-effective approach for treating municipal wastewater when considering the likely NPDES permit effluent limitations. Treatment Train E also has a very large carbon dioxide footprint, energy consumption….

The application of RO appears to be unnecessary, and is probably being considered because of the growing attention being given to "chemicals of concern" as well as priority pollutants. Based on the anticipated NPDES requirements, more cost-effective alternatives other than RO can be used by SCRSD to comply with potential requirements for "chemicals of concern".

The combined processes of MF, RO, and Ozone/Peroxide Oxidation will remove "chemicals of concern" such as endocrine blockers and many priority pollutants. If the goal is to reduce these "chemicals of concern" in the SRWTP effluent discharge, the cost of utilizing MF and RO should be compared with other alternatives. For example, sand or mixed media filters followed by activated carbon beds would prove effective in removing these chemicals and both of these technologies have been used in a number of tertiary treatment facilities. Also, the application of chemical oxidants with slow release catalysts have been developed for destroying priority pollutants…

One effective approach to removal of "chemicals of concern" is to design the Ozone/Peroxide Oxidation process to provide adequate chemical dosing and contact time to oxidize targeted chemicals to degradation products that result in their detoxification. Another approach is to add activated carbon adsorption beds. The addition of activated carbon beds would be compatible following either MF or mixed media filtration. Mixed media filtration and activated carbon have been used successfully in wastewater tertiary treatment plants. These combinations could be considered as alternative process sequences for Treatment Train E, if the removal of "chemicals of concern" is to be a future permit requirement.

Response: Treatment Train E was designed to expand the concept of "no net increase" under Treatment Alternative D by treating the projected 218 mgd future flow to provide removal of all target pollutants. One of the primary reasons that RO was included in Treatment Train E was to provide removal of TDS. In addition, Ozone/peroxide, in conjunction with RO, was added to the treatment train as these two processes provide multiple barrier protection for the removal of trace organics. This combination of treatment processes is the current best available technologies to remove trace organics. To our knowledge, there are no wastewater treatment plants of similar scale to the SRWTP that employ RO followed by ozone/peroxide.

Several of the specific comments are addressed below:

- We agree that MF/RO is not as cost effective of an approach to nutrient removal as biological nutrient removal processes. This comment is not relevant because the purpose for including MF/RO was to remove TDS, as well as other trace contaminants. RO is the best available technology for removal of TDS.
- As mentioned above, Treatment Train E was not designed to only meet the anticipated nitrate and ammonia limits, as this information was not available at the time of the development of the technical memorandum. As noted, Treatment Train E was designed to provide removal of TDS, as well as other trace contaminates.
- The goal is to not only remove "chemicals of emerging concern" but to also remove TDS. The suggested alternative treatment trains that consist of sand or mixed media filtration followed by activated carbon beds would not be effective at removing TDS.

Section V.A.

Comment: *Treatment Train M-C will achieve the same performance as Train C, but at a reduced cost by replacing MF with mixed media filters that have a preconditioning basin, using chemicals for flocculation and oxidation that will improve suspended particle removal. Cost savings is also realized by replacing the more costly UV Disinfection with Ozone/Peroxide disinfection. The process flow sequence is provided below.*

1. *Existing head works, followed by;*

2. *Existing pure oxygen system, followed by;*
3. *New NTF process, followed by;*
4. *New FBR for denitrification, followed by;*
5. *New chemical conditioning-flocculation basin, followed by;*
6. *New sand or mixed media filtration, followed by;*
7. *New Ozone/Peroxide Oxidation;*
8. *The Chlorine disinfection system would be abandoned*

Response: In the response to comments on Treatment Train C, these proposed modifications have been addressed previously above. Briefly, the use of sand or mixed media filtration instead of MF was considered for Treatment Train C. However, the HPOAS process used by SRWTP is challenging in terms of pin floc and conventional sand filtration performance. In Treatment Train C, replacing microfiltration with either sand or media filtration would potentially have an impact on final effluent quality with respect to particle concentrations and organic matter concentrations. Therefore, the poor performance of conventional sand filtration in reliably meeting Title 22 standards would make this alternative infeasible for SRWTP.

In any event, using ozone/peroxide instead of UV disinfection is not necessarily going to lead to cost savings. As noted before, the ozonation costs were based on a very low dose because the cost estimate was developed in the context of Treatment Trains D and E, where RO precedes ozonation. In addition, a non-proprietary ozonation or ozone/peroxide process would require CDPH approval to meet Title 22 standards. However, if alternative disinfection processes are considered for SRWTP in the future, a more detailed analysis of the costs of UV versus ozone/peroxide would likely be conducted. In addition, in the Technical Review the basis for costs are limited to capital costs. As noted previously, the selection of any advanced treatment facility would need to consider the total life cycle costs that include capital and O&M costs.

Section V.B.

Comment: *Treatment Train M-E is estimated to be $725 million less than Treatment Train E. Treatment Train M-E should be considered for two reasons. First, it utilizes MF rather than mixed media filters. It is recognized that SRWTP has conducted pilot studies with the MF process. The second reason is that mixed media filters require a relatively large footprint because of storage basins to hold wash and backwash waters for the filters. The cost savings for Treatment Train M-E results from removing the RO process and substituting NTF and FBR processes for ammonia and nitrate removal.*

If land availability is an issue, SRCSD could consider replacing the NTF option for nitrification with biofilters. Biofilters have a significantly smaller footprint than trickling filters, and they are

more consistent in performance for nitrogen removal.

Proposed Treatment Train M-E will meet requirements of the anticipated NPDES permit as well as DPH recommendations. The effluent quality would be equivalent to that of Treatment Train C. The process sequence for Treatment Train M-E is:

1. *Existing head works, followed by;*
2. *Existing pure oxygen system, followed by;*
3. *New NTF process for nitrification, followed by;*
4. *New FBR for denitrification, followed by;*
5. *New microfiltration; followed by;*
6. *New Ozone/Peroxide Oxidation;*
7. *Chlorine disinfection system would be abandoned.*

Response: While the modified Treatment Train E provides a reasonable approach to meet anticipated NPDES permit as well as DPH recommendations, it would not provide removal of TDS, and therefore would not provide equivalent effluent quality as the Treatment Train E developed in the Advanced Treatment Train Alternatives Memo. As noted previously, TDS removal was one of the objectives in the development of Treatment Train E.

Section VI.A.

Comment: *General suggestion to conduct pilot studies, with the possibility of using the existing WRF, to refine cost estimates.*

Response: The next logical step, if the SRCSD is required to install advanced treatment, would be to conducting pilot studies as part of further evaluation of potential advanced treatment trains. The investment in advanced treatment at SRCSD would be significant, and therefore, an upfront investment in pilot testing to refine cost estimates, assess feasibility, and evaluate process performance would be performed and the use of the existing WRF for pilot testing is possible, but would depend on the advanced process trains that were being considered and the SRCSD's commitment to supply recycled water to end users.

Section VI.B.

Comment: Utilizing biofilters for nitrification is projected to cost approximately $832 million in capital or $2.68 million per mgd. This compares with $2.13 million per mgd for the NTF process. This is a minor cost increase compared to the total cost and would result in a significantly smaller footprint than the NTF. This would also offset the increased footprint of the suggested mixed media filters over MF. Biofilters for nitrification is a hardware change and not a biological process change. Performance would also be better since biofilters are more

consistent in the degree of nitrification, resulting in the ability to achieve greater total nitrogen removal.

Response: The use of biofilters versus the NTF process is a decision that is best made during preliminary design. There are process considerations for both NTFs and biofilters that go beyond the scope and level of this evaluation. Since the cost of both is within the range of estimating accuracy, it is sufficient to leave the more conservative cost as a place holder until a more detailed feasibility assessment is made.

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FINAL PROJECT MEMORANDUM

Project Name:	SRWTP Advanced Treatment Costs	**Date:**	September 28, 2010
Client:	SRCSD	**Project No.**	7084B.00
Prepared By:	Steve McDonald		
Reviewed By:	Elisa Garvey, Vincent Roquebert		
Subject:	Review of Project Memorandum titled: *"Verification of Estimated Microfiltration Costs for Proposed Changes to the Sacramento Regional Wastewater Treatment Plant"*, (PG Environmental, LLC; August 27, 2010).		
Distribution:	Bob Seyfried, Vyomini Pandya		

PURPOSE

The purpose of this memorandum is to provide review comments on the project memorandum: *"Verification of Estimated Microfiltration Costs for Proposed Changes to the Sacramento Regional Wastewater Treatment Plant"*, (PG Environmental, LLC; August 27, 2010), hereafter the "PG Environmental Report".

BACKGROUND

The Central Valley Regional Water Quality Control Board asked PG Environmental to evaluate the microfiltration cost estimate provided in the project memorandum titled, *"Technical Memorandum - Advanced Treatment Alternatives for the Sacramento Regional Wastewater Treatment Plant"*, (Carollo Engineers, March 2009), hereafter the "Carollo 2009 Report".

The approach used in the PG Environmental Report to evaluate microfiltration cost estimate in the Carollo 2009 Report was based on "conducting a review of the available literature, eight unit construction cost estimates were identified that were used to evaluate the Carollo 2009 Report estimate", (pg.1, Section II, of the PG Environmental Report).

The findings in the PG Environmental Report are stated as follows:

- The literature estimates varied by approximately four orders of magnitude ($647 per million gallons per day or mgd to $3,200,000 per mgd).
- The estimates in the high end of the range were within the same order of magnitude as the estimate provided in the Carollo 2009 Report ($4,390,000 per mgd).

EXHIBIT D

- The median unit cost estimate, inclusive of the Carollo estimate, is $776,000 per mgd (2009 U.S. dollars).

COMMENT ON APPROACH AND FINDINGS

It is important to remain mindful that the costs found in the literature are typically either construction costs (or equipment costs), as stated in the PG Environmental Report. Consequently, our comments on the overall approach and findings of the PG Environmental Report are as follows:

- The Carollo project cost estimate in the Carollo 2009 Report includes all environmental studies, engineering, legal, administrative, and contingencies to deliver a complete project. Therefore, the microfiltration cost estimate provided in the Carollo 2009 Report is a project cost estimate, and cannot be compared directly to the construction cost estimates in the PG Environmental Report. The project cost factor to convert construction cost to project cost used in the Carollo 2009 Report is 65 percent. Therefore, although the estimated microfiltration unit project cost is $4,390,000 in the Carollo 2009 Report, the associated estimated microfiltration unit construction cost is $2,660,000. This is the second highest unit cost of the nine estimates in the PG Environmental Report (including the Carollo estimate).
- The large and precedent-setting scale of the proposed microfiltration membrane facility for the Sacramento Regional Wastewater Treatment Plant (SRWTP) would require a custom designed and constructed superstructure, pretreatment facilities, peak flow equalization basins, and other supporting utilities and structures. Therefore, it is not appropriate to assume that the unit costs from significantly smaller microfiltration facilities (less than 10 mgd), typically with equipment skid-mounted membrane units and relatively minor site preparation requirements, can simply be scaled up to treat 181 mgd average dry weather flow.
- The variation in the eight literature values provided in the PG Environmental Report is actually five orders of magnitude (not four orders of magnitude as noted in the PG Environmental Report). This only further reinforces concerns that the literature values are not based on the same membrane application, type of construction, flux rates, and supporting facility assumptions, much less upon the site-specific conditions at SRWTP.
- The Gurian and the ESCWA references included in the PG Environmental Report, we suspect are for mechanical strainers (e.g., they can go down to the 10 microns and still be considered "microfiltration" units); and not for polymeric

membranes. We believe no supplier can provide a polymeric membrane filtration system for $647 or $7,840 per mgd. These estimates are not appropriate for comparison.

- The PB Water (Zenon) and PB Water (Memcor) are likely equipment cost only. Carollo recently bid a 28 mgd drinking water project at medium flux rate, with the low bid coming in at $295,219 per mgd (Note: this is for membranes and holders only, and for a relatively clean drinking water application allowing for higher flux rates than would be expected on secondary effluent from the SRWTP high purity oxygen activated sludge process).
- The remaining four references vary from approximately $800,000 to $3,100,000 per mgd. Further investigation of the detailed project descriptions and drawings would likely show that the differences in cost are due to the difference in the type of structure and supporting services (e.g., from slab on grade and canopy, to full building with odor control and noise attenuation in an urban environment).
- Therefore, the median unit construction cost of the remaining four literature references, inclusive of the Carollo estimate, is $1,991,000 per mgd, and the mean unit construction cost is $2,700,000 per mgd.

CONCLUSION

The estimated unit construction cost provided in the Carollo 2009 Report of $2,660,000 per mgd is at the higher end of the range of the four applicable references that are most appropriate for comparison, and is reasonable and appropriate for the construction of a 181 mgd microfiltration membrane filtration facility treating secondary effluent from the HPOAS process at SRWTP based on a planning-level, Class 5 estimate (AACE International Recommended Practice No. 17R-97, pg. 2).